The SCIENTIFIC MONTHLY

VOL. LXIV February 1947 NO. 2

THOMAS A. EDISON AND CHARLES P. STEINMETZ, OCTOBER 18, 1922
See *Thomas Alva Edison*, page 109

PUBLISHED BY THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
A. A. A. S. Building, Washington 5, D. C.

THE SCIENTIFIC MONTHLY

VOL. LXIV February 1947 NO. 2

2,4-D, A POTENT GROWTH REGULATOR OF PLANTS

By H. B. TUKEY

Department of Horticulture, Michigan State College

THE plant growth regulator and herbicide 2,4-D has all the earmarks of being to the plant world what the insecticide DDT has been to the insect world. It appeared with suddenness, it has been remarkably effective, it is easily manufactured, it is relatively inexpensive, and it is safe and easy to handle. Its possibilities are only beginning to be explored.

But it is not alone the material, 2,4-D, that is important. It is what it represents. It represents a chemical attack on weeds, not by caustic agents that kill the plant by contact but by means of materials which regulate the growth of a plant and cause it to behave in such a manner that it is no longer suited to its environment. It is an effective approach toward weed control and promises results of far-reaching importance to agriculture throughout the world.

What, then, is 2,4-D? What are its properties? How is it used?

Correctly, 2,4-D is the abbreviation for 2,4-dichlorophenoxyacetic acid, which, as the name implies, is a halogenated phenoxy compound containing two chlorine atoms substituted in the 2 and 4 positions and having an acetic acid side chain. In popular usage, however, the symbol "2,4-D" has been used to mean any preparation that contains 2,4-dichlorophenoxyacetic acid or any of its salts, esters, amides, or related compounds. Thus, some manufacturers sell the water-soluble sodium salt of 2,4-dichlorophenoxyacetic acid, some sell the oil-soluble methyl ester, others sell the water-soluble ammonium salt, and still others sell the amide. Each formulation has certain virtues which the manufacturer extols, but all depend for their effectiveness upon their derivation from 2,4-dichlorophenoxyacetic acid.

2,4-D is manufactured by the chlorination of phenol (carbolic acid) to give a mixture of compounds with chlorine substituted in various positions in the ring. Fortunately, a high proportion of the mixture has chlorine in the coveted 2,4-positions (2,4-dichlorophenol) and is readily separated from the others by distillation. The next step is to neutralize the phenol compound with sodium bicarbonate to produce a sodium salt of 2,4-dichlorophenol, which is then combined with chloracetic acid to give 2,4-dichlorophenoxyacetic acid. The ease of preparation of 2,4-D and its low cost make it attractive for large commercial operations.

Its physical properties, too, enhance its usefulness. When refined it is a white powder with no offensive odor or caustic or corrosive action on skin or container. It seems nontoxic to animals at concentra-

tions commonly applied. Cows have been grazed on pastures sprayed with it with no harmful effects. Although found in the blood stream of the animal, it has not appeared in the milk.

2,4-D is applied in various ways. The acid itself is soluble in water only with difficulty. It must first be dissolved in alcohol and then in water or in some other solvent, such as one of the polyethylene glycols (Carbowax 200, 900, 1,500, etc.) which have proved so effective. The sodium and ammonium salts are, however, water-soluble and are generally as effective as the acid. Various esters are soluble in oil and may be used with formulations that involve oils, as emulsions.

Commonly, the active ingredient is applied in a water spray at the rate of 1 part per 1,000 by weight for herbicidal purposes. This very low concentration is in contrast to those of 1 to 10 and 20 more commonly met with in agricultural sprays. The trend is to use the material evenly distributed over a given area in more concentrated form so as to reduce the bulk required. This calls for refined apparatus and care in making treatments. Application in aerosol form, as when dissolved in dimethyl ether or some other liquefied gas, has proved effective, just as has DDT in aerosol bombs. For pastes and salves and other heavy concentrations for special purposes, lanolin may be used in combination with other solvents involving concentrations as high as 1 to 100 or 1 to 200.

But how did this come about? Who discovered 2,4-D? Who developed it?

As in any discovery and development of this kind, a number of individuals and laboratories have been concerned. If someone is omitted from the discussion which follows, it is not an error of intent.

It all started with growth regulators themselves. In a sense, any material that affects a plant may be called a regulator of growth, but by common agreement the term "growth regulator" has been left for a group of chemicals which do not enter into the make-up of the plant, as do fertilizers, but which in minute amounts produce characteristic changes or effects in growth, such as curvatures of stems and abnormal "formative" developments of foliage.

Hormones were recognized in animals before they were in plants. Beginning in the 1920's with the work of Boysen-Jensen, it became established that there were hormone-like materials in plants. Kögl and Haagen-Smit in 1937 were the first to isolate and identify one of these materials from plants. In the course of their investigations they identified indoleacetic acid as having growth-regulating properties. A great exploration began immediately among the lists of chemicals for others which had growth-regulating properties. Many workers in many countries were active in this field in the 1930's. Included in the group in this country were Went, Thimann, Haagen-Smit, Bonner, Van Overbeek, Avery, Burkholder, Zimmerman, Hitchcock, Kraus, Mitchell, Hamner, Marth, and Skoog. Zimmerman and Hitchcock, of the Boyce Thompson Institute for Plant Research, especially, kept methodically at the task of testing old materials and synthesizing and testing new ones.

Among the chemicals which were tested was one known as 2,4-dichlorophenoxyacetic acid, which was included in a list of materials having growth-regulating properties in a patent issued to Lontz and assigned to E. I. du Pont de Nemours and Company. It proved to be very potent in its regulating activities—so potent, in fact, that it was often injurious and was recommended to be used with caution.

During this period of activity in the pursuit of plant growth regulators, various practical uses were discovered, such as the rooting of cuttings and the prevention

of preharvest drop of apples. As early as 1941, however, it had been specifically suggested and demonstrated by Kraus, of The University of Chicago, that growth regulators had herbicidal properties and that if potent enough and cheap enough could be used in commercial practice. He initiated work at The University of Chicago with Beal and Hamner and with Mitchell, Hamner, and Marth at the U. S. Department of Agriculture. In 1944 he finally convinced the Chemical Warfare Service of the possibilities. Under the direction of Norman, a project was organized at Camp Detrick, under security policies, which included work in the U. S. Department of Agriculture and at Ohio State University. Among those identified with this work were Thompson, Swanson, Weaver, De Rose, Smith, Minarik, Boyd, Ennis, Allard, Taylor, Newman, Mitchell, and Brown.

In England, at the same time, work was going on independently and along similar lines in the laboratory of Blackman. Researchers included Nutman, Thornton, Quastel, Slade, Templeman, and Sexton.

To continue the story, in early 1944 Beal had published results of laboratory tests which suggested herbicidal possibilities with 2,4-D, and in the spring of 1944 Mitchell and Hamner, also from laboratory work, had published similar findings. In the summer of 1944, a paper appeared by Hamner and Tukey which reported successful field trials with 2,4-dichlorophenoxyacetic as a herbicide on bindweed and which spurred activity in this field of investigation on the part of those not bound by security regulations.

During this time Jones, of the American Chemical Paint Company, had been carrying on field trials independently. In late 1945 he was issued a patent on the material as a herbicide and vigorously pushed its manufacture and introduction to use. Other commercial companies took up the work, so that within a year production was measured in thousands of pounds rather than in grams, and the price dropped from $125.00 a pound to $3.00. Within less than 2 years, the commercial value of 2,4-D reached into millions of dollars.

Publications would have appeared likewise from the group working at Camp Detrick and from other laboratories had it not been for security regulations which prevented. These are now appearing and should be given full credit when history is finally written.

Field work in 1945 and 1946 from widely separated parts of the country and from Europe indicated great success with 2,4-D as a herbicide. The material seemed to move rapidly into the plant, to be transported in the direction of movement of synthesized material, and to be favored in its effectiveness by photosynthetic activity. Accordingly, greatest responses were secured from plants in sunshine. The action was the arrest in development of some parts of the plant and the stimulation of cell division and cell enlargement in other parts, especially in those regions which are young, active, and meristematic, such as cambium. Respiration was markedly increased, and starch reserves were depleted. The plants became bent and twisted and otherwise showed growth responses which were finally associated with inhibition and death. In some instances, plants were killed without apparent acceleration of growth in any part.

The below-ground parts of bindweed and sow thistle became proliferated, split, and decayed in the course of a week to 10 days. The pollen of flowers shriveled and became nonfunctional, leading to the use of 2,4-D to destroy ragweed pollen in an attempt to reduce hay fever. Many other plants, such as lamb's-quarters and pigweed, were killed.

Also, the material had been found selective in its action. For example, on blue-

grass lawns, infested with dandelion and narrow-leaf plantain, the dandelion and plantain were killed without injury to the grass. In general, it was found that grasses and cereals were not affected by concentrations that were toxic to broad-leaved plants; Bermuda grass proved an exception. This led to trials of grain fields with remarkable success. Wild radish, mustard, and similar weeds were eliminated from fields of young oats and wheat without injury to the oats and wheat. Rice was weeded by dusting from an airplane. The possibility was thus opened for wholesale treatment of cereals, including corn, although it was found that treatment must be made before the flowers formed in order to avoid injury to them. Alligator weed was killed in fields of sugar cane; water hyacinth was killed in ponds and ditches. With the ending of the war, some of the information which had been accumulated concerning the value of 2,4-D as a potent weapon in biological warfare was released.

2,4-D was found also to affect woody plants. As with herbaceous plants, it was found most effective in periods of active plant growth, in sunlight, at high temperatures, and in quantities sufficient to compensate for the size of the plant. That is, a small tree required less material than a large tree for a similar degree of response. Poplar trees which had been scored with a hatchet and treated on the cut surfaces with a paste or salve of 2,4-D split upwards for 30 feet. The bark proliferated and became spongy and soft and sloughed off. Pine trees similarly treated showed severe bending of the new growth and exudation of gum. Peach and cherry trees were killed by such treatment; exudation of gum from dead areas scattered over the entire tree followed. Elm trees were found sensitive, whereas hawthorn and juniper were less sensitive, and horse chestnut and oak were quite resistant.

Suckers from plum roots became twisted and finally died within a 3-foot radius of the cut surfaces of stumps to which a salve of 2,4-D was applied. Mesquite was killed by cutting close to the surface of the ground and then treating the new sucker growth with 2,4-D. Power companies and railroads found the material very effective against woody plants and climbers. By first cutting the plants and then treating the new sucker growth with 2,4-D, even stubborn woody plants were killed back into the roots and eliminated.

These were some of the results with 2,4-D which came rapidly to the front, extending all the way from selective lawn treatments to destruction of weeds in grain fields, tree eradication, clearing of rights of way and hedgerows, and actual clearing of land for farming.

A relatively new suggestion for 2,4-D is as a destroyer of weed seed in the soil. That is, instead of waiting for weeds to grow above ground and then treating them with a foliage spray, the 2,4-D is applied to the soil. Germinating seeds are more sensitive to 2,4-D than are seedlings or mature plants. Even grass seed may be inhibited and killed. After a period of time, depending upon the nature of the soil, the temperature, and the moisture, the 2,4-D leaches away or disintegrates, so that desired crops may be planted with no ill effects. The amounts applied have varied from 3 to 5 to 10 pounds per acre. Applications of 100 pounds per acre have freed soils of weed seed, but the toxic effect has persisted and the cost has been excessive. The period of time that must elapse after applications of the smaller amounts may vary from 2 to 8 weeks to over 6 months under cold or arid conditions. Some crops, such as peas and beans, are

more sensitive to residual 2,4-D than are others, such as corn and certain ornamentals. Results have been most satisfactory on sandy soils and least effective on muck soils. The details of treatment are yet to be worked out, but the idea appears promising.

Finally, 2,4-D has been found effective for uses other than as a herbicide and for killing weed seeds. If used with care it will effectively retard the preharvest drop of fruit. It can be used to promote the rooting of cuttings, especially those materials which root with great difficulty. It has been used to hasten the ripening of fruit. It will cause tomato flowers to set as fruit. It will reduce scald of apples in storage.

Undoubtedly other materials will be found that will enlarge the usefulness of growth regulators. The Camp Detrick group and their cooperators made and tested over 1,000 materials for their effect on plants. None has yet been found as generally potent or available or useful as 2,4-D, but possibilities are suggested and much has been learned. Some have been found, for example, which are effective against grasses and not so effective against broad-leaved plants—just the reverse of 2,4-D. And the shifting of only a single chlorine in the ring is shown to alter the effectiveness of the compound greatly.

All in all, the chapter dealing with 2,4-D and growth regulators is a fascinating one in the story of scientific discovery and development. It is one of those peculiar and too infrequent discoveries and developments in science in which many things have seemed "to go right." If a material is effective, it is often expensive, not available, difficult to manufacture, toxic to humans, explosive, or difficult to handle. But here is a compound which first proved effective against a few plants and selective in action, then proved effective against many plants, then proved not dangerous to humans at concentrations commonly employed and a "pleasure to handle," then proved so remarkably simple and inexpensive to manufacture as to become "the cheapest herbicide available today," and finally proved to have other uses than as a herbicide.

ESKIMO INFANTICIDE

By CLARK M. GARBER

Butler, Ohio

SURPRISING and tragic as it may seem, many Eskimo babies get only a brief glimpse of their mothers and the world's bright light before their barely-started existence as mortals is unceremoniously brought to an end. In other words, Eskimo mothers, under stress of unbearable economic conditions or through whims that have no foundation in reason, are known to destroy their babies. This merciless deed is accomplished in any one of several ways such as freezing, drowning, suffocation, etc. Girl babies are the usual victims because it is recognized that boy babies will grow up to become producers and providers.

Many of the world's prominent students of Eskimo ethnology have recorded their findings on this subject in widely scattered paragraphs of long out-of-print publications. I have collected all the important writings of an authentic nature on this subject and present them with my own observations and experiences for the enlightenment of the reader.

Jenness (pp. 165–166), in his illuminating discussion of the Copper River Eskimos, says:

> Often the parents are unwilling to rear their children, for a baby involves much hardship to the mother, especially in the summer when all the household goods are packed on the back. The child is only an additional burden to the mother up to the age when it can make a long day's journey on its own feet. Frequently the parents settle the problem by simply suffocating their baby and throwing it away.

In writing of his experiences and observations among the Alaska Eskimos, Dall (p. 139) says:

> Infanticide is common among them, both before and after birth. As an excuse, they say they do not want and cannot support so many daughters. Other women do not like the care and trouble of children, and destroy them for that reason. The usual method is to take the child out, stuff its mouth full of grass, and desert it.

Likewise, Dr. Sheldon Jackson (p. 115) mentioned the practice of infanticide among the Eskimos of Alaska. He said:

> Female infanticide is common among some of the tribes, particularly the Mahlemute and those of the Yukon. Many Indian mothers, to save their daughters from their own wretched lives, take them out into the woods, stuff grass in their mouths, and leave them to die.

Also, Dr. Boas (p. 580), in his account of the Central Eskimos, has something to say on this subject. He writes:

> Among all the tribes infanticide has been practiced to some extent, but probably only females or children of widows or widowers have been murdered in this way, the latter on account of the difficulty of providing for them.

Murdock (p. 417) is probably responsible for the only negative statement on this subject. He said:

> We never heard of a single case of infanticide, and, indeed, children were so scarce and seemed so highly prized that we never even thought of inquiring if infanticide was ever practiced.

This was probably just an oversight on his part, for had he taken the pains to investigate the possibility diligently, doubtless he would have found the Barrow Eskimos secretly taking the lives of their babies, especially girls.

In times of plenty very few cases of infanticide can be found. Famine and starvation, however, are not the only causes leading to infanticide. Occasionally, it happens that a fickle, mentally deficient

woman will give birth to a baby she does not want. In such cases there is a pronounced lack of motherly affection for the baby, and the mother may destroy her baby in a most diabolical manner. I have in mind the case of an Innuit mother of a very low type who killed her baby and fed it to the dogs.

Among the Innuits and Utes of Alaska, I have found both drowning and freezing the *modus operandi* for the destruction of unwanted children. On one occasion, I had departed from the village of Sfanagamute with my dog team, directing my course toward Nichtmute, the next colony. About half a mile out of the village, along the tundra trail, I came upon an infant lying among the snow-covered hummocks near the trail. Had I not possessed a well-trained lead dog, the infant would have been torn to shreds in less time than it takes to tell it. Stopping the dogs and making the sled fast, I picked the baby up and discovered that its body was still warm with life. After cleaning the grass from its mouth with my fingers, I wrapped it in furs, placed it on my sled, turned the dogs about, and headed back to the village I had just left. There I sought out the witch doctor and commanded him to find the infant's mother for me. When the baby's mother was brought to me, I gave the child into her arms and told her to care for it and raise it. The mother's apparent happiness at the recovery of the baby that she had put out to die convinced me that she had resorted to infanticide under stress of some economic necessity, perhaps starvation, widowhood, or illegitimacy. My subsequent inquiry brought to light the fact that famine and starvation had prompted the deed. I gave her such foods as I could spare from the provisions on my sled and provided her with an order on the trading post for additional supplies. Today, that same baby girl is a young married woman with a family of her own.

With the coming of the white man's civil code, the practice of infanticide by the Eskimos is dying out or is performed in utmost secrecy. Doubtless this accounts for Murdock's failure to discover evidence of the practice at Barrow. However, there are still existent colonies in which the deed is committed more or less openly.

Reasons for infanticide, as explained to me by Eskimo women and witch doctors, are the rigorous economics of their existence. Starvation, famine, or even a slight scarcity of food are the preponderant reasons given. However, there are other motives no less important, although they may not be so frequently cited as the factor of food supply.

Physical defects in newborn babies and multiple births often force the Eskimo mother to resort to infanticide. If a child is born physically deformed, it rarely survives the day of its birth. The general attitude toward deformed children is that they are simply no good; that they become helpless dependents and require ceaseless care to keep them alive; yet they are unable to contribute even the smallest effort toward the family's or colony's welfare. Furthermore, a child born deformed has little chance to stimulate any sort of affection in the breast of its primitive mother. In fact, the mothers of deformed children possess a distinct hate for their offspring and have not the least hesitancy in the matter of their destruction. During my long and intimate life with the western Eskimos, I found only two cases of living deformed children. In the village of Tanunak on Nelson Island, there lived a woman whose every child was born with its feet drawn back against its buttocks. By reason of missionary influence, these badly deformed children were allowed to live, and today they may be found hobbling about the village on padded knees. The other case, that of a clubfooted child, was found in the village of Kipnuk. It, too, was spared the inevitable fate of children born deformed.

Monstrosities have undoubtedly appeared among the Eskimos as a result of terrible malformations at birth. In the legends and stories of the western Eskimos there are many references to such monstrosities, most of them of the megacephalic type. The important or main theme in many of their stories and legends deals with children having heads of wolves, dogs, or seals, children with mouths extending from ear to ear, and children having the bodies and limbs of various animals. The fact that no such monsters are found living among them attests the efficacy of infanticide as a process of eliminating undesirables. An Eskimo child, in the settlements where primitive life still prevails, is indeed fortunate if born a male with sound and healthy body. Otherwise, the child's life probably would be short, especially if there were evidences of physical defects.

If twins are born to a western Eskimo mother and one of them happens to be a female, she is foredoomed to destruction. Twins are born to Eskimo mothers in about the same ratio as they are among the whites. However, one rarely, if ever, finds living twins among the Eskimos. Even though they do exist it is very difficult to identify them because they are usually separated at the time of their birth. If the twins are males, one of them is given away to some other family and promptly loses his identity because he then becomes a blood brother of the children of the adopting parents. In his discussion of this phase of infanticide, Jenness (p. 166) says:

> Where twins are born one at least must either be killed or given away, for an Eskimo woman cannot possibly rear both children at the same time. If one is a boy and the other a girl, it is invariably the girl that is made the victim. Boys, in fact, are seldom exposed, for they will support their parents when they grow up.

Some writers disclaim any knowledge of the practice of infanticide among the Eskimos. Perhaps they have not enjoyed the utmost confidence of the Eskimo people, which comes only after a long and intimate life among them. When they find it necessary to sacrifice the life of a child, it is not accomplished publicly, and rarely in a gruesome, murderous fashion. Particularly is this true if white men have established themselves in or near Eskimo colonies.

Let us examine the mental attitude of the average Eskimo mother who destroys her baby. Is she a murderess at heart? In some of the cases I have observed the mother has exhibited a pronounced love for her baby but had to squelch her affection in order that the older members of her family might continue their existence. On the other hand, some mothers have demonstrated a marked hardness and indifference toward the necessity for destroying their babies. Jenness (p. 166) likewise found this to be true among the Copper River Eskimos. He says, "A mother will do this, for apparently she has no spontaneous affection for her offspring at the time it is born." Fear of exposure may be an important factor in the killing of many unwanted Eskimo babies, although Eskimo girls who have babies out of wedlock usually rate only a severe scolding from their parents and are in nowise disgraced. But Stefansson (p. 215) states regarding the Cape Parry Eskimos, "Some women are afraid of their fatherless children and kill them at birth."

Although it is the child's mother who usually performs the actual killing, I have known cases in which the father either performed the deed or was instrumental in having it done. At the village of Kaskag on the Kuskokwim River, I knew a married man who had committed adultery with his stepdaughter. A child was born, and the father, having an intense dread of the penalty he might have to pay under the white man's civil laws, drowned the infant in the river. Under the Eskimos' primitive

status this deed would have gone unnoticed, or perhaps the child would not have been destroyed at all.

Naturally, the people of the civilized world look upon the primitive Eskimos' practice of infanticide as a diabolical thing. But, before we condemn them, let us consider well the cold, hard economics of their battle for survival and the manner in which many seemingly brutal practices are forced upon them by the exigencies of their very existence. Let us picture an Eskimo family or group of families living in a poor hunting ground or let us suppose a hunting season fails and leaves them stranded without any possible source of subsistence: they must then seek a more productive location. Such migrations, forced upon them during the long, severe winter, involve the transportation of the entire household. Utensils, bedding, tools, weapons, furs, hides, garments, and hunting and fishing gear must be hauled on the sled or carried on the back. Each member of the family must carry his share of the heavy load, and this does not exempt the women and children. If there should be a new baby in the family, the mother must decide whether or not the pack she must carry is more important than the infant. In most cases the decision is made in favor of the pack. Especially is this true if the infant is a female, in which case the child is put out on the tundra to perish.

Unfortunately, the primitive Eskimo apparently does not realize that there must be an adequate supply of girls if the increase and perpetuation of the race is to be assured. A persistent practice of infanticide has been known to produce a serious shortage of marriable girls, so that polyandry developed as a consequence. In one instance, I received word from the St. Lawrence Island natives that they were in need of a large number of marriable girls and was asked to send as many as possible from the mainland villages. Here is a concrete example of female infanticide carried to the extreme.

There is yet another phase of Eskimo infanticide that deserves special consideration. This is the destruction of the unborn by abortion. Throughout my close association with and medication of the Alaska Eskimos, I have not discovered a single case of voluntary abortion. If abortion does occur, it is more apt to be accidental than intentional. The very idea of destroying a child during gestation is repugnant to primitive Eskimo women. Not until they came into contact with the white man did they acquire the knowledge of how to destroy the evidence of their moral sins by prenatal infanticide. Several instances are known in which Eskimo girls were expecting to give birth to illegitimate children begotten by white men. To the uncorrupted, primitive Eskimo girls there is nothing evil in this sort of conception. But the white men, in order to save themselves from the penalties that would probably be visited upon them by the conventionalities of their own race, taught the girls whom they had wronged how to perform abortions on themselves. In many cases, such men have been known to pay dearly to have these abortions performed by others. Jenness (p. 167) says of the Copper Eskimos:

> One thing these natives have to their credit, however—they never resort to prenatal infanticide; I am not sure whether it is known even, although a native who quarreled with his wife when she was pregnant threw her down in the snow and rolled his foot on her stomach.

It cannot be denied, however, that abortions of an involuntary nature have occurred among the various groups of Eskimos from Alaska to Greenland. Dr. Boas (p. 426) found "abortion a contributing factor in the rapid diminution of the Eskimo population of Baffin Land." It is reasonable to believe that hardships, injuries, famine, and heavy work cause fre-

quent abortions among the pregnant women of Eskimoland. In fact, I have been called upon many times to treat Eskimo women for the hemorrhages resulting from involuntary abortion.

Eskimo witch doctors and medicine women, in their gross ignorance of the physiology of pregnancy and childbirth, sometimes, although unintentionally, cause expectant mothers to suffer unnecessary abortions. It is not uncommon for Eskimo women to consult the witch doctor for the relief of the common ailments of pregnancy. But the medicine man's ministrations are a far cry from the proper medical procedure in such cases. His method of treatment often takes the form of kneading the patient's abdomen with considerable force. Retching and vomiting are induced to remove the offending *jariax*, evil spirits, or devils, causing the sickness. This type of treatment is not only applied in cases of pregnancy discomforts; it is applied in many other kinds of sickness, so it cannot be labeled as a special treatment for producing abortion. The general attitude among the western Eskimos is that a pregnant woman has no desire to destroy the child within her body. To do this would constitute a serious offense against the spirit which controls the inspiriting of her unborn child. The Eskimos of the world inhabit the most difficult environment occupied by any of the races of mankind. They of course have no knowledge of the eugenics of childbirth and race perpetuation. Theirs is a blind, biological response to the rigid economic factors which control their lives from birth to death. Therefore, let us not judge them harshly for the strange and seemingly cruel customs and practices a merciless environment has forced upon them.

REFERENCES

BOAS, FRANZ. The Central Eskimo. Annual Report, Bureau of American Ethnology. 1884–1885.

DALL, WILLIAM H. *Alaska and its Resources.* 1870.

JACKSON, SHELDON. *Alaska and Missions of the North Pacific Coast.* 1880.

JENNESS, D. *The Life of the Copper Eskimos.* Canadian Arctic Expedition of 1913–1918.

MURDOCK, JOHN. Ethnological Results of the Pt. Barrow Expedition. Annual Report, Bureau of American Ethnology. 1887–1888.

STEFANSSON, VILHJALMUR. *Ethnological Report, Stefansson-Anderson Arctic Expedition.* American Museum of Natural History. 1914.

AMINO ACIDS*

By SIDNEY W. FOX
Chemistry Department, Iowa State College

AMINO acids are of fundamental importance partly because they are the molecular bricks of the proteins. There is no class of substance more intimately associated with the central processes of life than the proteins. Master hormones, antibodies, and enzymes are certainly proteins, and the genes almost certainly are. Many feel that the genes must figure importantly in a type of preventive medicine of the future; this is already true in the breeding of poultry which is resistant to disease and in the breeding of disease-resistant plants. Viruses, hemoglobin, membranes, muscle—even hair, skin, and nails—are proteins. The proteins are the building stuff of the body. They are also the agents that do the building and maintain the repairs. The substances which, in the laboratory, come closest to having the power of self-reproduction, are proteins. The proteins in turn are essentially larger molecular combinations of amino acids. This is the fundamental reason for the interest of the pharmaceutical and other industries in amino acids.

The amino acids which have been recognized as constituents of protein are almost two dozen in number. The earliest methods for their preparation depended largely upon hydrolysis, or chemical digestion, of proteins. Synthesis has been relied on increasingly for preparative purposes. Methods of manufacture must be selected on the basis of the specific purpose in mind. One very important criterion related to such selection is based on the fact that amino acid molecules are capable of existence in two forms, a left-handed and a right-handed form.

This relationship is quite analogous to the relationship between left-handed and right-handed gloves. It is a significant fact that amino acids which are found in nature are almost exclusively left-handed, or *levo*; the right-handed, or *dextro*, type is practically absent from protein. The human organism is capable of using only the levo form of many of the amino acids. When amino acids are isolated from protein by hydrolysis with acids or enzymes, they are of the desired levo form. When they are prepared by total synthesis they consist of exactly equal amounts of the levo and dextro forms. The latter are usually undesirable, which frequently means that synthesis has an inherent disadvantage. It is, however, possible to synthesize two pounds of some amino acids more cheaply than to isolate one pound and subsequently to employ two pounds of synthetic amino acid even though only one-half of it is active.

On one hand, cheaper methods of synthesis are continually being developed; on the other, isolation procedures are also undergoing improvement. When new proteins with unexpectedly high contents of certain amino acids are found, the costs of these amino acids are of course lowered. This sort of knowledge develops especially from systematic study of proteinaceous by-products; fish-processing fractions, for instance, have yielded pleasingly large quantities of some amino acids, such as arginine. It is interesting to note that the cheapest amino acid, glutamic acid,

* From an address delivered to the thirty-ninth annual meeting of the American Pharmaceutical Manufacturers' Association at Lake Louise, Canada, on June 10, 1946.

which is obtained from protein, is available in quantity at less than $1.00 per pound. The simplest amino acid to synthesize, aminoacetic acid, is on the market at over twice as much. Some of the sources of isolated amino acids seem also to be capable of improvement by crop breeding, somewhat as are other characteristics like acreage yield and blight resistance. In cooperation with the United States Department of Agriculture, we are carrying out in our laboratories in Iowa a project for increasing, by breeding, the content of lysine, tryptophan, and other amino acids in corn. In accordance with the belief that it is unsafe to predict whether synthesis or isolation will eventually provide the most economical methods of production for individual amino acids, we are also attempting to develop better syntheses of lysine and tryptophan. It is our intention, however, to follow up the breeding possibilities for each amino acid which may be of commercial value.

One reason for the interest associated with increase of lysine and tryptophan in corn is closely related to what has been the principal concern of the pharmaceutical industry in amino acids—as a therapeutic form of protein nutrition.

A little history of this subject may be in order. The tissue proteins are constantly wearing away and need to be replaced by fresh protein. In the normal human being, this is accomplished after digestion of food protein in the stomach and intestines. The resultant amino acids and small combinations of amino acid molecules, which are called peptides, are carried to various sites and are synthesized into the particular tissue, hormone, or other protein required. When there occurs in the digestive apparatus an abnormal condition such as intestinal obstruction, peritonitis, peptic ulcer, carcinoma, or nonfunction due to near-starvation, it is desirable to by-pass the usual digestive "disassembly line." Proteins such as casein and egg albumen which we get in normal food cannot be injected directly into the blood stream because they will produce serious reactions.

, Human blood proteins can be injected, but they are quite expensive. One answer to this problem is to introduce into the blood the building units which are normally there after a meal and which are normally employed for the purpose—amino acids and peptides.

These principles were appreciated by the European biochemist Emil Abderhalden over thirty-five years ago. Abderhalden and co-workers, in one of their experiments, hydrolyzed a quantity of beef in the presence of enzymes from the gastrointestinal tract. The patient was one Konrad Gegner, a twelve-year-old boy who had drunk the contents of a glass of lye. The lye induced a stricture of Konrad's esophagus which finally prevented his taking food by mouth.

From September 1 to September 15, 1909, Abderhalden's hydrolyzate was administered to Konrad by rectum. During this period the patient retained nitrogen and actually gained a little weight. Abderhalden had demonstrated that human protein nutrition could be effected by nonoral administration of predigested protein. This seems to be the first record of protein hydrolyzate utilization by a human patient.

Abderhalden also realized that in his mixture some of the amino acids were critical. If tryptophan were destroyed, for instance, the resulting mixture was not properly retained by dogs.

It was not until twenty-six years later, when pure individual amino acids had become available in sufficient quantity, that McCoy, Meyer, and Rose, working with rats, determined just which amino acids are critical. Today eight amino acids are known to be required simul-

taneously in order that any of them be properly retained by adults. These eight are isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine; they are known as essential, or indispensable, amino acids. The word "essential," used in this way, is not always interpreted in the manner originally intended. Many of the amino acids which are not called essential are actually indispensable to life. For instance, thyroxine, the amino acid which is substantially the active principle of the thyroid gland, is one without which we could not live. The body is capable, however, of making thyroxine from phenylalanine, a so-called essential amino acid. "Essential" in this connection thus means that the amino acid is required but cannot be synthesized by the body rapidly enough; it must be included in the diet. It is furthermore true that for over-all protein nutrition, a minimum amount of each of the eight essential amino acids must be present in the mixture.

Nor is this the whole story. Many investigators have observed that completely hydrolyzed protein is not equivalent in nutritional value to the original whole protein. It has recently been announced by Sprince and Woolley that many proteins liberate on proper partial hydrolysis a factor (strepogenin) which enhances the value of amino acid mixtures in nutrition. Strepogenin is not an amino acid itself; it appears to be a peptide intermediate between protein and amino acids. When added to mixtures of the amino acids, strepogenin increases their value to mice and rats. When the strepogenin effect has been adequately evaluated, the use of synthetic amino acids for protein nutrition will be closer at hand.

A REASON sometimes quoted for the rising interest in amino acids is the belief that they will have a history similar to that of the vitamins. There are similarities and there are differences. One important difference is in the amounts required. Spectacular cures of vitamin deficiency diseases are achieved with milligram amounts of vitamins. The necessary daily intake of amino acids is, however, several hundred times, in weight, that of the vitamins required.

Much work is going on in an attempt to determine specific amino acid deficiency states comparable to that for vitamins. This field can be expected to move ahead with the aid of the new microbiological assay methods of Max Dunn and others. Interest in individual amino acids is, however, not restricted to their use in treating deficiency states. Some examples follow.

The largest market that exists for a single amino acid is undoubtedly that for glutamic acid. The relatively pure monosodium salt of glutamic acid has been used in the Orient for about thirty years as a meat flavor and provides a considerable industry there. In the past decade monosodium glutamate has become popular in the United States. The resultant large-scale manufacture partly explains the low cost of this amino acid.

Glutamic acid, because of its basic amino group, combines with hydrochloric acid to provide a source of hydrochloric acid in which the strong acidity of the latter is masked. Glutamic acid hydrochloride therefore is used as a therapeutic agent for the introduction of gastric hydrochloric acid.

Glutamine is a glutamic acid derivative which is of interest because it has the natural function of detoxifying certain organic acids. Glutamic acid, because of its low price especially, is also of potential value as a chemical intermediate. In our laboratory we have been able to synthesize plant hormones and weed-killers of an otherwise expensive type from glutamic

acid, and it appears that it will be more feasible to obtain a new series of compounds in this family.

Glutamic acid thus presents accomplished and potential utilities as an industrially useful material, as a chemical intermediate, as a biochemical intermediate, and as a pharmaceutical agent. These utilities, plus perhaps that of curing deficiency states, represent some of the chief ways in which individual amino acids are likely to develop markets.

Another amino acid of value for combating toxic substances of various sorts is aminoacetic acid, or glycocoll. This is known scientifically as glycine, but is labeled otherwise in the trade because another compound, used in photography and incorrectly dubbed "glycine," is poisonous. The detoxifying effect of glycocoll has been known for some time, and many of the early Ehrlich-type drugs were combined with glycocoll to diminish the toxic effects of the drugs themselves. In the modern era, the coadministration of glycocoll with such medicinals as sulfapyridine has been claimed to lower toxicity effects.

Another amino acid available at a relatively low price is tyrosine. Tyrosine has a chemical structure in common with antioxidants, so that its probable use for this purpose was predictable. Tyrosine, like other amino acids, is not oil-soluble, but on simple conversion to an ester it becomes oil-soluble and retains its antioxidant properties. The objection of toxicity raised to other antioxidants such as hydroquinone is not so valid here. The esters of tyrosine are accordingly receiving some attention as antioxidants in the pharmaceutical and food industries.

Biochemically, tyrosine is probably a precursor of thyroxine, the amino acid which is substantially the active principle of the thyroid. Tyrosine is believed to be converted physiologically into thyroxine in two reaction steps. Simulation of these reactions in glassware has resulted in low yields of thyroxine. Synthetic thyroxine, by a devious procedure, has been available for two decades but not at a price which could compete successfully with thyroid powder. Further improvement of the process, starting with tyrosine, could change this picture.

Tyrosine is also believed to be a natural precursor of epinephrine, an important hormone. In our laboratories we are preparing iodinated tyrosine derivatives which are of interest for X-ray photography.

Another amino acid that promises some special utilities as a detoxifying agent is methionine. Methionine has been successfully used to treat hepatitis of the type caused industrially by TNT or carbon tetrachloride. Reports are also appearing which indicate that methionine may be useful in treating infective hepatitis, or jaundice. New syntheses have made methionine available in quantity.

Cysteine, which is also of biological value as a detoxicant, is an intermediate in the commercial synthesis of biotin. There is evidence for other amino acids functioning biologically as intermediates for vitamins. The conversion of alanine to pyridoxine and the conversion of aspartic acid to a part of pantothenic acid are examples.

To return to specific uses of amino acids, the lack of arginine in the diet of the male rat has been shown to result in lowered production of sperm. This fact suggested arginine therapy for idiopathic hypospermia, and some cases have responded with definite stimulation of spermatogenesis. The entire study was related to knowledge of the long-established fact that spermatozoa are known to contain considerable quantities of arginine.

Histidine has for many years been used in the treatment of gastric and duodenal

ulcers. Protein hydrolyzates have been recommended for this utility also, and oral administration suffices in this latter case.

Histidine is also closely related to histamine, which is produced from the former both biologically and chemically. Histamine is important because it is a causative agent in allergy and shock. Histamine has been used as a desensitizing agent itself. Histamine is also the gastric hormone. The appetizing effect of soy sauce can be attributed to the fact that soy protein has been hydrolyzed: one of the constituent amino acids was histidine, and during the hydrolysis some small part of this is converted to histamine, which in turn induces the characteristic peristaltic hunger response.

It is worth noting that for many of the most common maladies, such as cancer, heart disease, and hypertension, there is no question but that proteinaceous substances and, therefore, amino acids are intimately involved. There are not sufficient data on which to render any prediction as to how amino acids will be utilized in the treatment of such diseases or, indeed, if they will be utilized as pharmaceutical agents at all. We can be sure, however, that the growing knowledge of the reactions of the amino acids in glassware and in the organism will contribute to the solution of these medical problems.

As an example of how such knowledge may add to understanding, one may consider the relationship of amino acids to antibiotics. Bacteria, pathogenic or otherwise, require, as we do, amino acids and proteins for their substance. Some bacteria can synthesize all of their own; others require substantially the same "essential" amino acids as we do. The form required is here also generally the left-handed type.

In the competitive struggle for existence among microorganisms some creatures have developed antibiotic substances that interfere with the growth of others. This in fact defines an antibiotic. One of these substances, gramicidin, produced by *Bacillus brevis*, is a molecular combination of amino acids, as are many other antibiotics. The striking feature of gramicidin, however, is that 45 percent of its amino acids are of the dextro, or "unnatural," form.

It has been found in our laboratories that the growth of many bacteria could be slowed down by the simple dextro amino acids and that products obtained from these structures by chemical conversion also had this effect, in some cases more so than in the parent structure. These simple substances are not so powerful as the antibiotics, but they offer some very suggestive leads. When the secrecy regulations covering penicillin were relaxed in December 1945, it was reported that the pencillin class of antibiotics is also derived from the peculiar right-handed amino acid structure. A fundamental relationship between dextro amino acids, evolution, and therapy thus seems to be involved. There is some evidence that the right-handed amino acids and the antibiotics function by interfering with the activity of enzymes which normally influence the reactions of "natural" molecules.

One further point: alkaloids such as quinine, morphine, pilocarpine, and others which are produced by some plants are believed also to arise in general from amino acids. This suspected relationship has led to some beautiful experiments by Robert Robinson, in England, in which a few alkaloids were synthesized in laboratory glassware, under physiological conditions, from the indicated precursors. It has also led to some attempts, in at least a few laboratories, to lower the cost of preparation of individual alkaloids by synthesizing them from amino acids.

In conclusion, definite lines of genealogy can be drawn from the amino acids to

proteins, vitamins, alkaloids, hormones, antibiotics, and other substances of biological importance. Some of these relationships are so basic that they account for a large amount of research activity in this field. The established value of amino acid therapy in the form of protein hydrolyzates is a matter of clinical record, notably in a series of articles in the *Journal of the American Medical Association*. Some individual amino acids have definite value as pharmaceutical agents and as chemical intermediates; other uses of this sort will without doubt be developed. The place of individual amino acids in the treatment of specific deficiency states is beginning to receive evaluation. There can be no question that the amino acids are of great value in furnishing understanding in various fields of therapy.

BEYOND TIME AND SPACE

A gentleman of England eyed
A falling apple, threaded a maze
Of tangled thought, and thence descried
The invisible sweep of the force that sways
The universe; an Austrian abbot
Tended garden peas and saw
The working of inscrutable law
That molds all life in age-long habit
Of growth; a lover of wisdom in
A Prussian town, strolling each day
Along the same somnific way
Explored the farthest realms within
The reach of reason.

A gentle Jew,
Inscribing symbols, quietly
Encompassed all infinity;
A wrathful one leafed slowly through
A dusty mass of data stored
In rows of books at London's hoard
Of learning, like a cleric drudge—
And found the lever that would budge
The world.

The probers who pursue
The quest of knowledge are the new
Explorers; their minds range past the reach
Of plodding flesh to scale or breach
Or vault the barriers that can
Immure the groping thoughts of man.

WILLIAM NEWBERRY

THOMAS ALVA EDISON

By CHARLES F. KETTERING

As HAS been its annual custom for the past fifteen years, America will this month again pay tribute to Thomas Alva Edison, the man who, many believe, contributed most to making the world a better place in which to live. But this year February 11 has a special significance—it is the hundredth anniversary of Edison's birth.

Edison's influence has of course been widely felt. Of particular interest to members of the A.A.A.S. is the little-known fact that in 1880 he made possible the launching of *Science*. The full story of this venture into journalism will be told in the February 7 issue of that weekly. I, personally, as a member of an industrial research organization, wish to pay tribute to Edison as the pioneer organizer of a research group. In 1870, after he had received payment for improving the stock ticker, he set up business in Newark, N. J. Perhaps it was not so clearly evident to the young Edison as it is to us nowadays just how difficult it is to conduct research, engineering, and manufacturing all under one roof. We realize today that these are three distinct stages in converting an idea into a reality, and the time interval separating each of these stages may run into years. Edison's keen mind, however, quickly grasped the fact that something was wrong: he could not develop his ideas and manufacture things with the same facilities, so he turned over

PRESENT INTERIOR OF THE EDISON LIBRARY, WEST ORANGE, N. J.


EDISON AT FOURTEEN

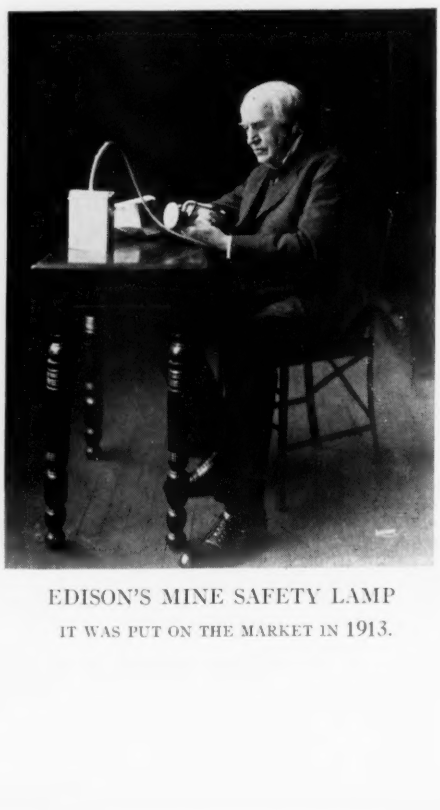
the factory to a competent superintendent and moved to Menlo Park where he could concentrate undisturbed on ideas. But he had more new ideas than he had time and hands to work out. As a result, he made probably one of his greatest contributions to mankind—he collected around him a group of brilliant men who could help him explore the many channels opened by his fertile mind. Today, organized research is the basis of most technical progress, and we owe a great debt to the man who led the way over seventy years ago.

These are things that touch upon the scientist's specific interests, but people in general are more interested in the inventions of Edison that have directly affected their daily lives. As our most prolific inventor, he surrounded us with many conveniences that now form an integral part of our lives. He gave us light, the phonograph, the motion picture; his carbon button transmitter made the modern telephone possible; and he developed the fluoroscope as an adjunct to radiography.

In the twentieth century we take these things for granted, as we do also the industries that grew from Edison's handiwork—industries that have an estimated value of \$20,000,000,000 and some 4,000,000 employees.

In Edison's laboratory at West Orange, N. J., there stands on a pedestal a cubic foot of copper. History tells us that some thirty-four years ago the members of the copper industry gave a luncheon for Edison to express their appreciation of what he had done for their business. They asked the inventor what they might give him in acknowledgment of his great contributions. Edison thought a moment and then replied that he had never seen a cubic foot of copper—maybe they could give him one. That is how this unusual exhibit came into his possession.

That cube of copper stands today as a symbol of what can happen when an inventor brings from the limitless storehouse of the unknown a new fact. On the day in October 1879 when Edison produced the first commercially practical incandescent electric lamp, the copper industry went about its usual daily routine, unaware that


EDISON'S MINE SAFETY LAMP
IT WAS PUT ON THE MARKET IN 1913.

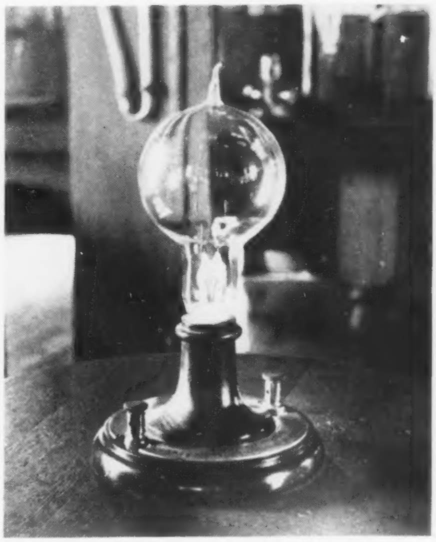
its future history was being written in a little laboratory in New Jersey.

On the trail of the new electric light came New York City's Pearl Street Powerhouse, the first central station. Copper went into the dynamo coils and commutators; it went into the switches and the many miles of transmission cable. The production of the metal went from 50,000 tons to the present production of approximately 1,000,000 tons. And the jobs came, too—manufacturing jobs, service jobs, and selling jobs. All because one man found a way of producing light by heating a carbon filament in an evacuated glass bottle.

There are few examples that so clearly show the difference between a *patent* and a *product* as the development of the incandescent light filament. The first lamp on which Edison obtained a patent in 1879 contained a platinum filament, but the inventor was not satisfied. He tried carbonized cotton thread and eventually produced a commercially practical incandescent lamp. He felt, however, that this was not the answer, and further investigation uncovered bamboo as an improvement. He spent thousands of dollars financing a search in the jungles of South America for the best type of bamboo for his purpose. As we all know, the search has never ceased—the adventures with tantalum and osmium and the struggle to make brittle tungsten into filament threads are too well known to repeat here.

With the coming of electric light and power hundreds of other things followed—radios, electric stoves, vacuum cleaners, refrigerators. New industries were born, and new jobs were created by the thousands.

As a creator of jobs Edison has had few, if any, equals. When in 1887 the idea of the motion picture occurred to him, he again set the stage for innumerable new jobs and occupations that no one at the time could even imagine. Who could have predicted that hundreds of thousands of miles of film



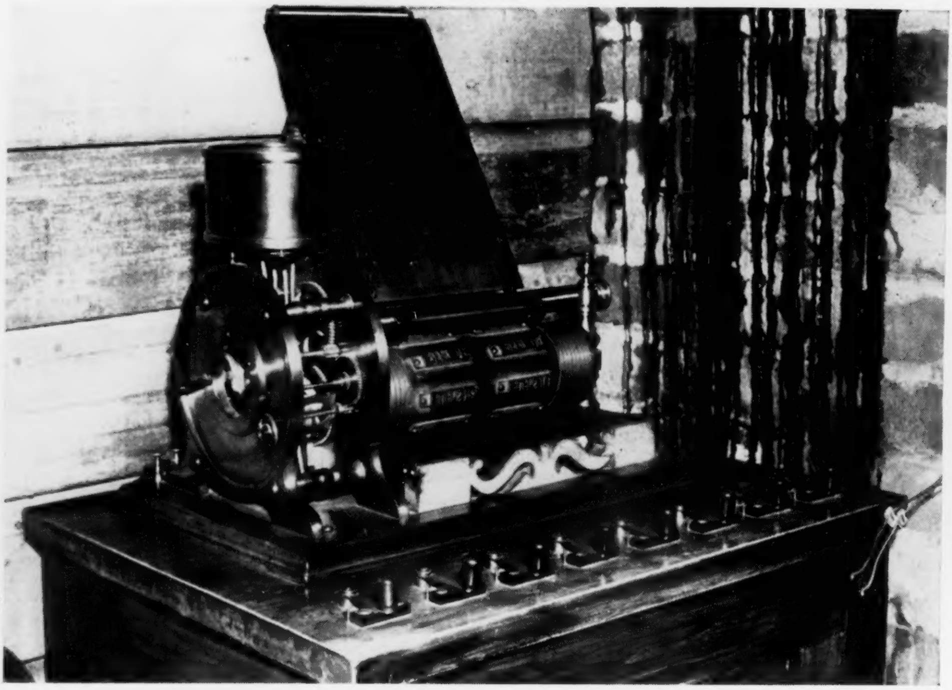
REPLICA OF ORIGINAL LAMP

MADE BY EDISON AT DEARBORN, MICH., AT THE CELEBRATION OF LIGHT'S GOLDEN JUBILEE.

would be produced annually and that motion-picture theatres would be built in every town in the United States? The effect of the first flickering shadow on a silver screen has been felt in every home in the nation.

These are the high lights of the results of just *two* scientific studies made by *one* man. Edison was an outstanding example of the combination of the theoretical and the practical in one person. We are not always so fortunate in having such a combination and for this reason often have two or more men working on a project. At the time Edison was patiently working night and day, with comparatively crude laboratory apparatus, to discover basic principles, the public was of course quite unaware that this one man was shaping the America of Tomorrow. This is typical of any scientific development in its first stages—we never know just how important it may become. And so researchers are diligently doing the same type of work in their laboratories today.

Who knows what an idea is worth? In the case of Edison we cannot judge by his

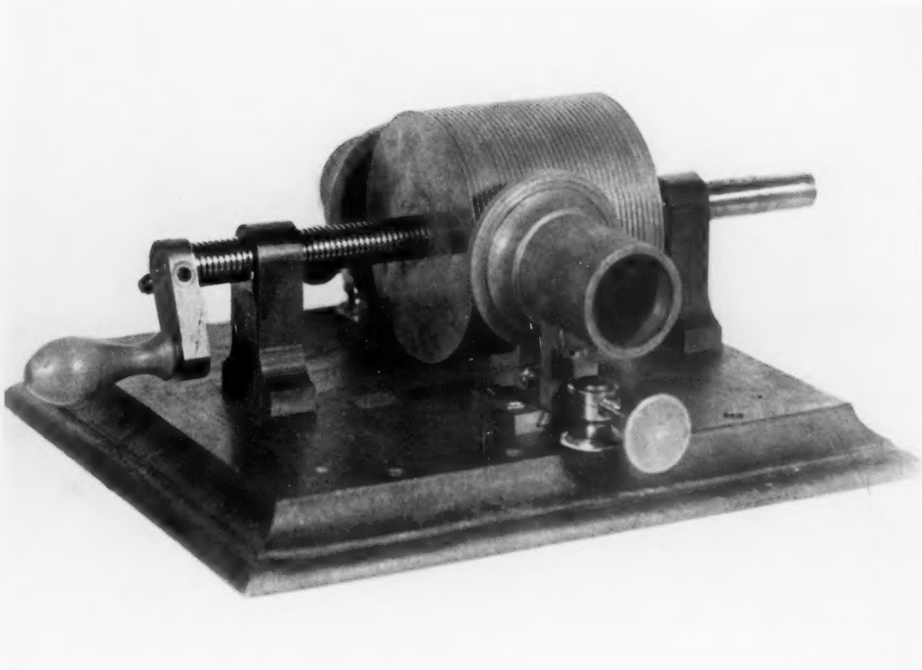


MODEL OF EDISON'S FIRST PATENT

THIS ELECTRICAL VOTE RECORDER WAS PATENTED IN 1868.

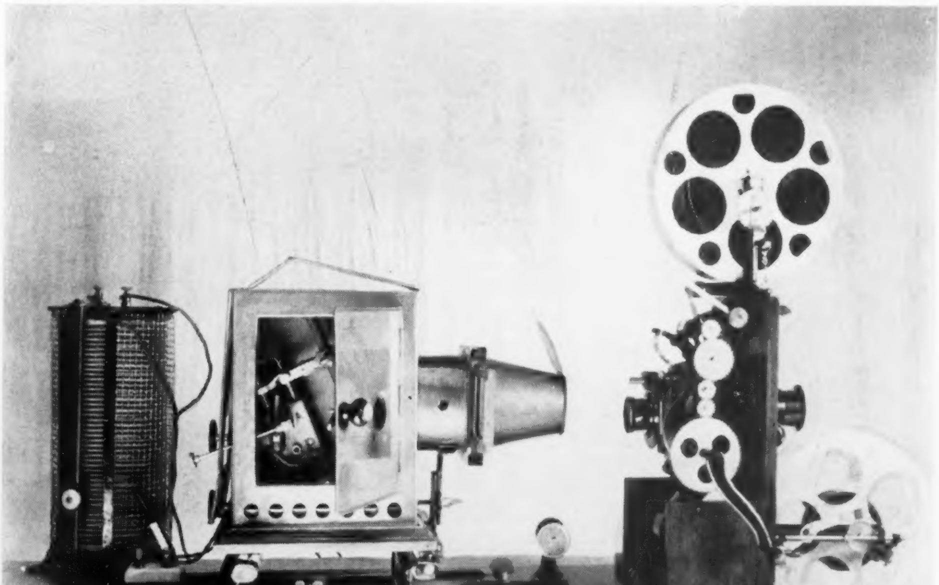
EDISON'S UNIVERSAL STOCK TICKER OR PRINTING TELEGRAPH

MANUFACTURED BY HIM IN NEWARK IN 1872 FOR THE GOLD AND STOCK TELEGRAPH CO.



THE ORIGINAL TIN-FOIL PHONOGRAPH

ON AUGUST 15, 1877, THIS MACHINE FIRST RECORDED AND REPRODUCED THE HUMAN VOICE.



EDISON'S PROJECTING KINETOSCOPE

ONE OF THE EARLY MODELS OF ABOUT 1902 OR 1903.

THE FIRST MOTION-PICTURE STUDIO

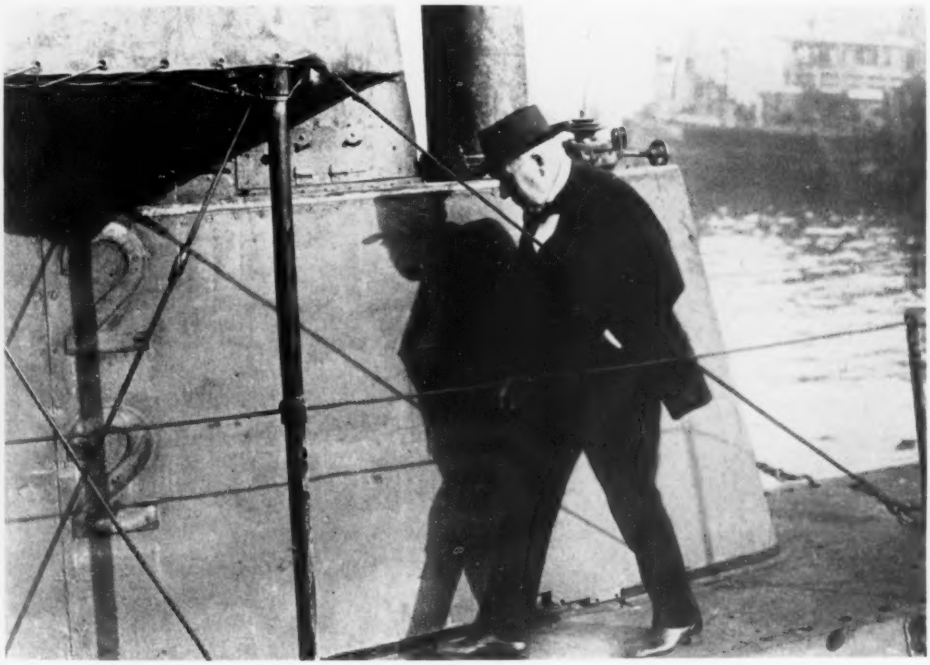
THIS BUILDING, CALLED "THE BLACK MARIA," WAS BUILT IN 1892 AND WAS AMERICA'S FIRST STUDIO FOR TAKING MOTION PICTURES. THE BUILDING COULD BE REVOLVED TO GET DIRECT SUNLIGHT ON THE STAGE.

EDISON WITH AN EARLY SOUND-SYNCHRONIZING MOTION-PICTURE CAMERA, 1905

AFTER PERFECTING THE PRINCIPLES OF MOVING PICTURES, EDISON TURNED TO EXPERIMENTS FOR SYNCHRONIZING SOUND TO ACCOMPANY THE FILMS. PHOTOGRAPH TAKEN IN HIS LIBRARY IN WEST ORANGE, N. J.

THE INSOMNIA SQUAD, 1910

EDISON FREQUENTLY WORKED FOR LONG STRETCHES OF TIME WITHOUT REST. HERE HE IS SHOWN WITH SIX OF HIS CO-WORKERS AFTER NEARLY 48 HOURS OF CONTINUOUS WORK ON THE DISC PHONOGRAPH RECORD.



EDISON INSPECTING WORLD WAR I SUBMARINE, 1915

EDISON WAS HIGHLY INSTRUMENTAL IN THE MOVE TO CREATE SCIENTIFIC RESEARCH DEPARTMENTS IN THE ARMED FORCES. THUS, THE NAVY DEPARTMENT STARTED ITS NOW FAMOUS NAVAL RESEARCH LABORATORIES.

EDISON'S HOME IN LLEWELLYN PARK, WEST ORANGE, N. J.

personal gain because that was infinitesimal when compared with the great increase in our national wealth brought about by the use of his ideas. How can we personally evaluate his contributions? The only way I can possibly do this is to imagine that we were suddenly deprived of all those things for which he was responsible. Let us try to imagine our world without electric power lines—no lights, refrigerators, stoves, radios, or other electrical appliances. Let us think of our towns without motion pictures, telephones, and street cars. What would we not give to have these things returned to us?

In the hundred years since Thomas Alva Edison was born in Milan, Ohio, his inventions have changed modern civilization as have those of no other man. Many people say that he was a genius, but he himself once said, "Genius is 1 percent inspiration and 99 percent perspiration." He clearly recognized the great truth that lies back of every worth-while contribution of mankind—the foundation of civilization's progress—that man will always move forward as long as we have open minds and willing hands.

PROGRESS IN CORK CULTURE IN THE UNITED STATES

By GILES B. COOKE

Research Department, Crown Cork & Seal Company, Baltimore

FOR more than 6 years the intensive, expanding program to grow cork trees in this country has made outstanding progress. Established by the late Charles E. McManus, former President and Chairman of the Board of the Crown Cork & Seal Company, the Cork Project is designed to add to the natural resources of our country and to provide in the United States a source for at least a part of the nation's cork requirements. Since its inception the Cork Project has developed from a few experimental plantings in 1940 to large, extensive plantings in 22 states in 1946. Interesting research has accompanied this rapid increase in cork planting, and already much valuable knowledge has been acquired. Thousands of little cork oaks are now growing throughout the warmer half of the United States, and tons of acorns of this much needed tree are planted annually in the potential cork areas of this country. With the splendid cooperation of federal and state foresters and the aid of local vocational agriculture teachers and county farm agents, the Cork Project has passed the trial stage and is now a proved, stable program. Six years of successful background have given confidence and determination to those planting and growing cork trees.

CORK-ACORN DISTRIBUTION

Annual cork-acorn collections have increased rapidly, and the entire domestic crop is needed for planting. Demands for seed greatly exceed the available supply. In the fall and winter of 1945-46 more than 5 tons of cork acorns were obtained in California, and this quantity was several tons short of meeting the requests. Cork-acorn distribution during the past 6 years is shown in the following table:

YEAR	POUNDS OF ACORNS
1940–41	500
1941–42	1,450
1942–43	7,500
1943–44	7,900
1944–45	13,800
1945–46	10,200

All these acorns, except for approximately 200 pounds collected annually in Arizona and the South, were obtained in California.

Courtesy, Crown Cork & Seal Co.

A CORK TREE IN WINTER

THIS EVERGREEN CORK TREE, NOW 3 FEET IN DIAMETER AND 60 FEET HIGH, PROVIDES SHADE AND BEAUTY AT "LAUREL HILL," COLUMBIA, S. C.

Some of the acorns were planted in California and Arizona, but the bulk of them was distributed in the Eastern, Southern, and Southwestern states. In the far South the acorns are planted early in the year—just as soon as distribution can be made. Approximately one-half of the total col-

lection is placed in wet cold storage and held for several months. These are distributed in the cooler areas each spring as soon as freezing weather is past. Not only has the annual distribution of acorns rapidly increased, as tabulated above, but also skill and technique in planting has improved. Knowledge obtained in the first years of the program has been used to give a higher percentage of germination of acorns and better survival of seedlings.

In addition to the California acorns, some seed has been obtained in Europe and North Africa. Cork acorns have been imported from Spain, French Morocco, and Algeria. A large shipment by boat in 1944 arrived in very poor condition, and subsequent importations have been of smaller quantities. Some acorns were brought from North Africa by airplane.

METHODS OF PLANTING

Three methods have been used for planting cork trees, and each has definite merits. Propagation of the cork oak may be effected by planting cork acorns in permanent locations, planting acorns in individual containers and later transplanting to permanent sites without exposing or damaging the roots, and planting acorns in a nursery, removing seedlings in bare-root condition the following year and transplanting in permanent sites. Up to the present time the cork tree has been planted only on areas of limited size.

The easiest and simplest way to grow

Courtesy, Crown Cork & Seal Co.

A TRUCKLOAD OF ACORNS OF THE CORK OAK

HUNDREDS OF THOUSANDS OF CORK ACORNS LIKE THESE ARE COLLECTED AND DISTRIBUTED ANNUALLY THROUGHOUT THE WARMER HALF OF THE UNITED STATES.

Courtesy, Crown Cork & Seal Co.

CORK ACORNS ARE DISTRIBUTED TO CHILDREN

MEMBERS OF THE 4-H CLUB IN SCOTLAND COUNTY, N. C., ASSEMBLE TO RECEIVE THEIR CORK ACORNS FROM E. O. McMAHAN, COUNTY AGENT.

cork trees is to plant acorns where the trees are to grow. More than one-half of the cork acorns collected are planted in this manner. Three acorns may be placed in each site; when planted in this way a good cork tree at every spot is obtained. Protection against squirrels, other rodents, and livestock must be provided. This method avoids future transplanting, which is often accompanied by root damage and plant shock.

A limited number of the acorns are planted in cans or paper pots. When the seedlings are 5 to 8 inches high they are placed in permanent locations. Survival of seedlings planted by this method is very high—over 95 percent. The small loss is due largely to damage incurred in transit. This method is not practical when thousands of plants are distributed, but it is excellent for limited quantities.

Bare-root seedlings have been transplanted successfully with good survival, but unless all conditions are just right the loss is often high. Very often, either during shipment or after being received, the roots become dry, which is fatal to the plant. Also, in many cases the seedlings receive root damage, with resulting plant shock, and growth is retarded. When more is known about this method of planting cork trees it may be used more extensively.

CORK PLANTINGS

Many plantings of the cork oak for ornamental purposes have been made.

Courtesy, Crown Cork & Seal Co.

CORK PROPAGATION

THIS ROOTED CORK CUTTING, TAKEN FROM A MATURE CORK TREE, IS THE RESULT OF PATIENT, CAREFUL RESEARCH.

The heavy, evergreen foliage and the light-gray bark give the cork tree a pleasing, attractive appearance throughout the year. Governors in 9 states, recognizing the beauty as well as value of this tree, have planted and dedicated a cork tree on the grounds of their respective state capitols. One-acre or larger groves of cork oaks have been planted by a number of colleges and universities. After a few years these groves will be valuable, beautiful additions, serving for study and research as well as being recreational areas. Other plantings have been made in parks, about schools and other public buildings, and along highways. Many private plantings about homes and on farms have been made to secure attractive shade trees.

Cork trees are planted every year in those states having a climate favorable for the growth of this variety of white oak. Two general methods are used, the choice of procedure being made by the cooperating state.

A substantial supply of acorns is sent to the state forestry departments. The greater portion is distributed directly to interested planters, and the remainder is planted in the state forest nursery. Seedlings grown from the acorns are usually distributed when one year old. The procedure varies slightly in the different states. In some states all the acorns are distributed as soon as received; in others some acorns are distributed and the rest used for growing seedlings. Both methods have merit, but up to the present time acorns have given better results with the average planter than seedlings.

In the past two years large quantities of cork acorns have been distributed to high-school boys and girls. Cork plantings by these interested young people are arranged through the Department of Forestry, the Department of Education, or the Extension Service in the various states. Cork acorns are sent at the proper planting time to the Vocational Agriculture Teachers,

Courtesy, Crown Cork & Seal Co.

FROM AN ACORN

PLANTED IN THE WINTER OF 1942-43, THIS YOUNG CORK TREE AT COLLEGE STATION, TEX., HAS GROWN TO A HEIGHT OF MORE THAN 8 FEET.

for Future Farmers of America, or to the County Agents, for the 4-H Club members. The enthusiasm and determination these boys and girls are showing in growing cork trees is resulting in thousands of young cork trees for this country every year.

PLANTING RESULTS

Because of the tremendous number of acorns and their extensive distribution, a check on the plantings is as yet incomplete. However, the known results are generally good. Acorn germination ranges from 50 to 80 percent, which is high considering the period in cold storage and, in some cases, the long distances traveled in shipment. Cork seedlings show a very high survival rate (95 percent) when shipped with earth in paper pots and planted without exposing the roots. Bare-root seedling loss is much higher, owing chiefly to serious root injury in lifting or to the roots becoming dry while out of the ground.

In all the states outstanding growth has been made by certain trees, demonstrating clearly what the cork oak will do under favorable conditions. The fastest growth has been made where the growing season is long and rainfall generous.

STRIPPING MATURE TREES

More than 500 cork trees have been stripped of virgin cork since the initiation of the McManus Cork Project. This cork has been manufactured into various products and given thorough, exhaustive tests. Most of these trees are in California, but cork has been removed from approximately 20 trees in Arizona and the Southern states. Composition cork and corkboard insulation made from this cork were of excellent quality, and the domestic material was found equal in every way to imported cork of the corresponding grade.

Growth of reproduction cork on the stripped trees is very satisfactory. In 1944, on 35-year-old trees stripped in 1940, new cork formation was three-quarters of an inch thick. In 1946, 6 years of growth yielded cork almost one inch thick from these trees, and 1.5 inches of cork had grown on older trees. The second-growth cork was, like the virgin bark, found to be of excellent quality. Annual domestic cork stripping now involves the removal of reproduction as well as virgin cork, and before long third-growth cork will be taken from the California trees each year along with first and second strippings.

The following table gives a summary of cork strippings by years:

Year	No. of Trees Stripped	Yield of Cork (lbs.)
1940	248	10,561
1941	47	2,142
1942	63	3,466
1943	46	2,735
1944	54	3,216
1945	58	3,538
Total	516	25,658

RESEARCH

Along with the extensive planting of cork acorns and seedlings much valuable research on cork culture is conducted by the Cork Project.

Methods of storing cork acorns received early attention. The acorns are very perishable and must be given special care if they are to remain viable for 6 weeks or longer. Cold-storage tests showed the acorns can be kept several months at 34° to 40° F. if not allowed to become dry. This has been of great value in distributing the perishable seed at the proper planting season to the cooperating states. During the past several years tons of cork acorns have been kept viable for 2 to 4 months in wet cold storage.

Cork acorns are collected with much care. To avoid leaves, grass, and other extraneous material the acorns are collected by picking. This is very important in storage as the presence of dead organic matter often re-

Courtesy, Crown Cork & Seal Co.

STRIPPING CORK

SECOND-GROWTH CORK IS HARVESTED FROM A TREE AT CHICO, CALIF., JULY 1946. THE VIRGIN CORK WAS TAKEN FROM THIS TREE IN 1940.

sults in mold development when the acorns are removed from wet cold storage.

The cork oak has been successfully grafted to native oaks. Successful grafts have been made at the Fruitland Nurseries, Augusta, Ga., and the Masonic Homes, Elizabethtown, Pa. Mirov and Cumming have shown that scions of the cork oak can be grafted to both evergreen and deciduous American oaks. This method of establishing cork-oak groves is under observation; it will be some time before the complete story is known.

The rooting of cork cuttings is another method of propagation that has received serious attention. This method was first successful at the Fruitland Nurseries in 1943, and since then a limited number of rooted cuttings have been obtained each year. Tests are being continued until the method can be reduced to a routine. Cuttings, like scions for grafting, are taken from mature trees having thick, resilient cork and bearing a large crop of acorns.

Some of the cork plantings made in 1942 and 1943 have shown remarkable growth. One tree at Hastings, Fla., which was an 8-inch seedling in June 1942, measured 3.5 inches in diameter and 12 feet in height in June 1946. Evidently this tree has had very favorable growing conditions. In order to determine what plant food elements are needed by the cork tree a special experiment is being conducted. Cork seedlings in sand are being grown in the presence and in the absence of plant food elements. This research should show what elements a cork tree needs for good growth.

Bare-root cork seedlings are difficult to transplant. The cork oak has a long taproot, frequently with few lateral roots. Special research on the root pruning of cork seedlings in the nursery has been in progress several years. When these tests are completed survival of transplanted cork seedlings may be much higher.

CONTRIBUTIONS OF ENTOMOLOGY TO THEORETICAL BIOLOGY

By CHARLES T. BRUES

Biological Laboratories, Harvard University

DURING the past century, which has seen such a rapid development and changing outlook in the several biological sciences, the insects have served a major purpose in furthering theoretical deliberations as well as factual knowledge. This is a natural consequence of the abundance and diversity of these small animals, for they are the most numerous of all specialized organisms. With this in view, following a personal acquaintance with the insects extending over nearly half of this period, I have been tempted to recapitulate briefly and in a very general way their contributions to the biological mill, laying stress on matters where they have functioned particularly well as objects for close observation or experimental laboratory investigation.

In dealing with theoretical biology, it must be admitted that one inevitably encounters wide divergence of opinion as to what may be hypothetical, theoretical, or generally accepted as established and fundamentally sound. Several concepts have passed through these successive stages only to retrograde and lapse into oblivion. Others which have withstood continued scrutiny remain theoretical only in the sense that their early history betrays the mark of prophetic expectancy, dampened by the inevitable skepticism that greets any innovation.

Many readers will at once assume that the greatest of all contributions by insects are those that have led to what is familiarly known among biologists as "Drosophila genetics," based at first on a single abundant species of small fruit fly and later extended to other members of the same genus. Such a supposition would be much nearer the truth were we concerned only with the most recent developments in biology.

A mutation of this little pomace fly (Drosophila), discovered by chance, formed the beginning of a most remarkable and rapidly unfolding panorama of biological discoveries, one which has gone far over a period of several decades toward furnishing an insight to the complicated mechanism of inheritance. It happens that the small flies multiply rapidly and abundantly when confined in bottles in the laboratory, where many successive generations and large populations may be studied with a minimum of time and effort. Furthermore, most probably because they belong to a recent group of insects at present in the throes of rapid evolutionary change, they appear particularly prone to produce mutations, anomalies, atavistic regressions, and imperfections of true hereditary nature. To all this is added the fact that there are only four paired chromosomes, within which all the hereditary characteristics are crowded, instead of the greater number present in most other animals and plants. Finally, the actual morphology of these chromosomes may be examined, owing to the very unusual circumstance that in one single organ (the salivary gland) of this particular order of insects (Diptera), and here alone, the chromosomes become so hypertrophied that their minute structure is clearly revealed by the microscope to a degree not paralleled elsewhere among living organisms. It would seem that Divine Providence had set the stage and pointed out the fruit fly as a chosen object for biological inquiry. Nevertheless, it just happened this way, and an obnoxiously prolific insect has come to occupy the center

of the biological stage. A few competitors have been unearthed, but they are clearly second-rate, and none other has so beautifully fulfilled the requirements for a perfect experimental animal. The field of Drosophila genetics has fast expanded but appears to have by no means reached its final stage of cultivation. So far its fruits have added little directly to an understanding of evolution or speciation, but the application of taxonomic and mathematical methodology to studies of the numerous species of Drosophila is now breaching the wall that appears to cloister some hitherto wholly undisclosed workings of the evolutionary process. These revelations, particularly with reference to the fixation of mutational changes in population groups of dissimilar size, are already being applied to some evolutionary problems of great concern to paleontology. If nothing else, they have served to bring genetics and paleontology into closer accord, a most desirable accomplishment which bids fair to speed progress in both these branches of biology.

Drosophila has thus given to the world a second contribution, this time to pure science. It was dependent upon, and followed closely on the heels of, Mendel's discovery of the independence of unit characters in inheritance.

The first contribution of Drosophila lies on a far lower intellectual level and should perhaps not be mentioned here since it came to earth, not as a child of theory, but as a practical gift to several of our earlier civilizations. It relates to the now well-known fact that the common Drosophila flies disseminate the yeasts on which their larvae feed in decaying fruits and that they quite universally infect grapes with these organisms, thus preparing them for the fermentative process which results in the production of wine. This valuable service was totally unappreciated by the ancient wine makers, and its true significance was recognized only a few years ago when biologists began to probe into the dietary regime of the fruit fly. By laboratory experiments they determined that yeasts form a major component in its meal of rotting fruit and that the aroma of the alcohol thus arising serves to whet the fly's appetite quite as well as our own. Incidentally, it must be noted that the studies of yeasts as food for Drosophila occupied an essential place in the early development of our knowledge concerning the nature and significance of accessory food substances. These in turn have played a major role in advancing our knowledge of the physiology of nutrition, not to mention the compounding of "vitamins and minerals" into pills with which the American public now doctors itself to the tune of some millions of dollars annually. Added to its large interests in the liquor industry, this is quite a financial coup for a little fly risen to fame from a cradle of rotten fruit.

One of the original bulwarks of the principle of natural selection was the idea of protective resemblance whereby animals escape notice by predatory enemies as the result of a modified exterior which simulates some common object in the environment. In the case of insects this may frequently be a leaf, twig, a bit of bark, or even a bird dropping. Among all animals, the most outstanding examples of this phenomenon are to be found in insects like the phasmid leaf-insects and walking sticks of many genera. No less striking are certain butterflies, culminating in the genus *Kallima*, where the wings simulate dry leaves when folded over the back in their resting position. Commonest among such camouflaged insects are numerous green caterpillars whose bodies fuse visually into the play of light and shade on the vegetation they frequent. This multiplicity of camouflage presented everywhere by insects is by far the strongest evidence for the development of such characters through natural selection and was so recog-

nized early by Darwin and Wallace, both of whom had enjoyed the opportunity to observe many examples in nature. This was particularly true of the latter during his wide experience in the Malayan Islands, notable for the tropical exuberance of their insect fauna. It may be fairly said that through the years the insects have furnished the bulk of material which the work of numerous observers has welded into an elaborate framework demonstrating that protective coloration and protective resemblance represent very decisive phases of organic evolution, readily visualized as effected through the action of natural selection.

Closely associated with the idea of protective resemblance and usually mentioned in the same breath is that of warning coloration and mimicry; indeed, we may almost regard the latter as an offspring of the former. If so, we must unfortunately damn it as an illegitimate child, for it has been by no means uniformly received with good grace in polite biological circles. Most of the outstanding examples are met with among the insects, particularly butterflies, moths, flies, and certain beetles, and they involve both form and color, often to a degree so convincing that all doubt vanishes and no questions are asked. In the case of butterflies the difficulty arises at the assumption that the model is unpalatable and that it successfully advises its predatory enemies of this fact by a warning pattern in brilliant color, gradually acquired through natural selection. This theory assumes a good memory in insectivorous animals, such as birds, lizards, and other insects, a careful choice of tasty morsels on their part, and perhaps even ancestral memory to speed up the process beyond a negligible rate. The existence of such peculiarities has never been proved. To further complicate the matter we know that certain of these butterflies are polymorphic forms of a single species mimicking different species of other butterflies. Moreover, the polymorphic color forms are Mendelian phenotypes, differing from one another by unit characters.

Original

PHYLLIUM SICCIFOLIUM

A LEAF-INSECT RELATED TO THE WALKING-STICK.

In the case of moths, flies, and beetles that resemble stinging wasps, mimicry seems far more plausible, especially to those of us with tender skins, neurotic dispositions, or allergic tendencies. Again, such has not been proved for insectivorous animals and many of them, including such diverse forms as bears, skunks, lizards, and robber flies are not deterred by such protective devices.

The idea of orthogenesis, determinate evolution, or predestination as propounded by Eimer is essentially a matter which turns to paleontology for evidence of its validity. The assumption that evolution proceeds by steps that are determined by intrinsic factors without the guidance of natural selection, at least during the incipient stages, is more generally acceptable to paleontologists than to experimental biologists. The former have "seen it happen" in structures as diverse as the teeth

of mammals and the shells of ammonite mollusks, long cited as classical examples. Consistent changes follow the beam and may proceed with undiminished vigor toward a point where they appear, to all intents and purposes, clearly detrimental to their possessors. So far, it seems that the reality of orthogenetic evolution cannot be denied but that its existence is incompatible with any assumption that the individual

MIMICRY IN SWALLOW-TAIL BUTTERFLIES, *PAPILIO*

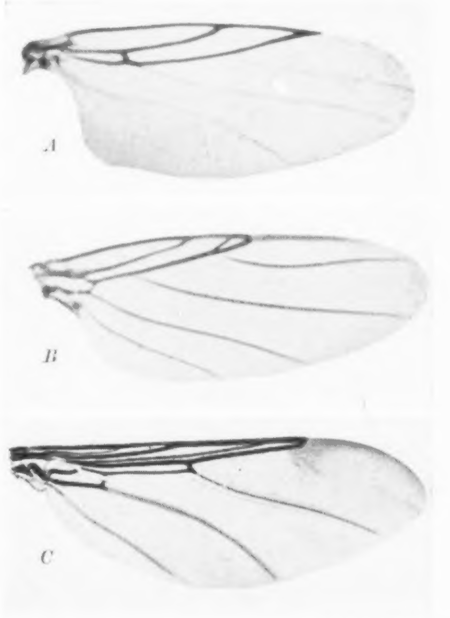
FEMALES OF THE MIMETIC *Papilio polytes* OCCUR IN THREE VERY DISTINCT FORMS (SHOWN AT *A*, *C*, AND *E*). THE VARIETY *cyrus* (*A*) CLOSELY RESEMBLES THE MALE. THE VARIETY *polytes* (*C*) APPEARS TO MIMIC A POISONOUS SPECIES, *P. aristolochiae*, SHOWN AT *B*. THE VARIETY *romulus* (*E*) APPEARS TO MIMIC *P. hector*, ANOTHER POISONOUS SPECIES, SHOWN AT *D*. THE THREE POLYMORPHIC FEMALE FORMS OF *Papilio polytes* ARE KNOWN TO BE INTERBREEDING MENDELIAN FORMS.

genes reproduce themselves in perpetuity without variation or change other than that due to chance mutations of random nature. However, if gene mutations are either directly or indirectly dependent upon molecular constitution, we must reasonably expect some definite pattern of change to be evident. As we cannot hope to see manifest changes occurring within the period of a few human generations, direct experimental evidence is obviously not to be anticipated, even though we may cheerfully pass the buck to the genes. Painful aspersions have been cast on confessions of ignorance concerning the nature of intrinsic factors responsible for orthogenetic evolution, and it has been far too generally stated that biologists are thus led to embrace the tenets of metaphysical or theological vitalism, both of which are first-class anathemata to modern science. Nevertheless, there is still a good deal of meat in the belief that honest confession is good for the soul, even though the entity named may be nothing more than an impelling figure of speech.

Patently, insects can have played small part in formulating or furthering any orthogenetic doctrine, for a knowledge of paleoentomology is as yet far behind that of many other groups of animals, despite very substantial progress during recent years. Nevertheless, the insects, in connection with the color patterns of butterflies, furnished some of the critical material on which Eimer's original ideas were based.

Other insects of the order Diptera have also offered an interesting side light in connection with the degeneration of the wings, organs which form a complex, morphologically integrated unit. In several families of these flies it is noticed that an extreme simplification of the wing venation occurs whereby some members of certain families (Scatopsidae, Ceratopogonidae, Phoridae, and Hippoboscidae) develop very similar configurations. Although we know that all these have not been developed from a single ancestral type, the loss of veins has proceeded to an almost identical pattern. Here there is no recrudescence of atavistic morphology, as the primitive venational type is the most complex to be found in this order of insects. This convergence in simplification is clearly in the nature of an orthogenetic process, resulting perhaps as a reduction through the casting out of specific genes during evolution. This is exactly what most commonly happens, for example, in apparently random mutations as observed in the most studied insect, Drosophila, also a member of the same order Diptera. It is, however, not haphazard but an orderly process and remains at present inscrutable, nonetheless so when pushed back into the realm of ultramicroscopy.

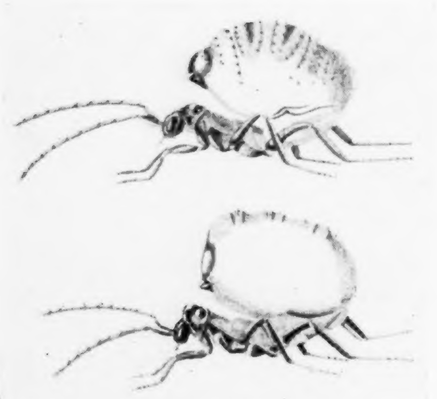
A similar convergence in degenerative pattern is seen in certain small parasitic



C after Bequaert

WINGS OF FLIES

WINGS OF SEVERAL UNRELATED FAMILIES OF DIPTERA, ILLUSTRATING STRIKING CONVERGENCE IN THE VENATION, COINCIDENT WITH A REDUCTION OF THE WING VEINS. *A*, *Scatopse* (SCATOPSIDAE); *B*, *Phalacrotophora* (PHORIDAE); *C*, *Lynchia* (HIPPOBOSCIDAE).



TWO STRANGE BEETLES

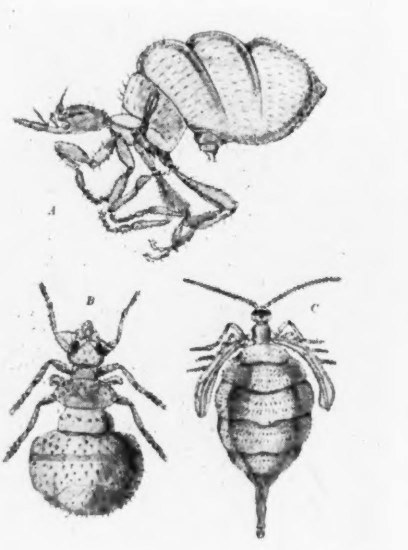
THESE STAPHYLINIDS REPRESENT EXTREME CASES OF PHYSOGASTRY. FROM THE ORIGINAL FIGURES OF SCHIÖDTE, WHO FIRST MADE KNOWN THIS REMARKABLE TYPE OF BEETLE.

Hymenoptera belonging to several superfamilies, where the wing venation is reduced to an isomorphic configuration evolved independently from the more complex one characteristic of the generalized members of each group.

A peculiarity known as physogastry is developed by various insects, especially staphylinid beetles and flies of at least two families that live as termitophiles, exclusively in the nests of various tropical termites. The abdomen of these physogastric forms is enormously distended till they become grotesquely deformed, presumably in response to the excess of highly nutritious food with which they are stuffed by their overzealous termite hosts. To some extent this satietal morphology represents a postmetamorphic stretching of the intersegmental membranes like that of the still more severely affected termite queen and as such has no more genetical significance than the goose that supplies *pâté de foie gras*. Here, however, it represents a purely developmental or genotypical conformation. Moreover, it has been shown that two independent lines of physogastric beetles have arisen, one in the Old World and another in the New World, each leading through a separate series of genera to a remarkable similarity in physogastric modifications. This convergence obviously cannot have arisen through a loss of genes, and, further, it must be admitted that the whole process is permeated by a strongly Lamarckian flavor. As there may be hormonal peculiarities involved, these termitophiles present an interesting problem for more precise experimental investigation.

EVER since the doctrine of organic evolution and the unity of life infiltrated biological thought, it has been noted that the rate, or tempo, of the evolutionary process is by no means uniform. This is true when we consider the large groups or phylogenetic units among animals, and similar discrepancies are commonly encountered among the members of much more restricted categories.

The insects present many examples of



After Wasmann and Silvestri

TERMITE-LOVING FLIES

THREE SMALL TERMITOPHILOUS DIPTERA SHOWING SIMILAR PHYSOGASTRIC MODIFICATION IN UNRELATED FAMILIES. *A* AND *B* ARE OLD-WORLD FAMILY TERMITOXENIDAE. *C* IS TERMITOMASTUS, REPRESENTING A TOTALLY UNRELATED NEOTROPICAL FAMILY.

this kind. Thus, the cockroaches, constituting the order Blattodea, have persisted since the Upper Carboniferous and during this long period have undergone only minor changes in comparison with other living orders of insects, most of which did not come into existence till much later. We may attribute such persistence to type over the ages to greater fitness and hence comparative freedom from the action of natural selection. Such indeed was the earlier and readily plausible interpretation. However, it is a far stretch of the imagination to regard these generalized creatures as even appreciably better adapted to their environment than the highly specialized types of insects of much more recent origin. That they are highly versatile must be admitted, but this adaptiveness appears restricted to their behavior, a matter to which we shall return in a moment. Not only these insects, but other arthropods, illustrate this phenomenon beautifully, stripped quite completely of any behavioristic connotations. We refer to the scorpions and still abundant king crabs.

Original

A FOSSIL ANT

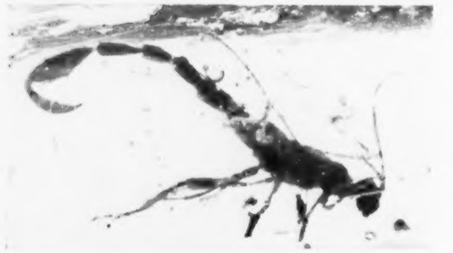
THIS SPECIES, *Lasius schiefferdeckeri*, IS ABUNDANTLY PRESERVED IN BALTIC AMBER. LIKE THE FORMICA MENTIONED IN THE TEXT, THIS SPECIES IS NEARLY IDENTICAL WITH THE VERY COMMON LIVING *Lasius niger* OF EUROPE AND NORTH AMERICA. THE PARASITIC MITE WHICH IS TO BE SEEN ATTACHED TO ITS LEG IS MUTE EVIDENCE THAT THE TERTIARY ANTS HAD ALREADY FALLEN PREY TO SUCH PARASITES.

Original

A FOSSIL COCKROACH

THIS SPECIMEN FROM THE UPPER CARBONIFEROUS OF MAZON CREEK REPRESENTS A PRIMITIVE ORDER OF INSECTS THAT HAVE UNDERGONE LITTLE EVOLUTIONARY CHANGE OVER A VERY LONG PERIOD OF TIME.

The insects have furnished many more specific examples of this variation in the tempo of evolution, which has become a topic of increasing interest to a considerable number of biologists concerned with the problems of speciation and has, in a highly speculative form, already entered the field of Drosophila genetics. So far as our present knowledge goes, the ants appear full-fledged at the dawn of the Tertiary, and there is good reason to believe that they had not been long in existence at that time. Yet, in the Oligocene the most abundant ant (exquisitely preserved in Baltic amber) is really not specifically distinct from a dominant species of Formica that now ranges widely over both Europe and North America. Together with it are extinct genera and species having no close counterparts in the world today, as well as members of other genera where speciation has proceeded at a more moderate though active



Original

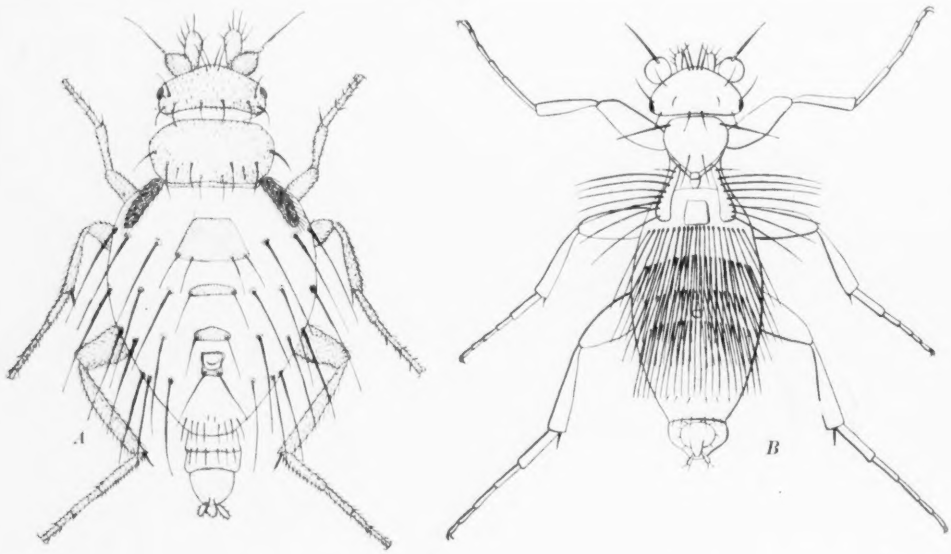
A FOSSIL PARASITE

Pelicinopteron tubuliforme, AN OLIGOCENE PARASITIC HYMENOPTERON IN BALTIC AMBER. A PECULIAR TYPE WHICH IS THE SOLE REPRESENTATIVE OF AN EXTINCT FAMILY.

tempo. Similar discrepancies are encountered among other amber insects, and since this extinct fauna is incomparably better preserved than any other of equal age, it presents the clearest picture yet available for a study of this kind.

This particular case of the Oligocene Formica so fully authenticated, falls directly in line with the statistical expectation of slow evolutionary tempo in large and flourishing populations as contrasted to a rapid change predictable for small populations. It would appear that among these ants the complex social organization of the more specialized subfamilies, including the exploitation of Mother Nature's food supplies, has met with the most surprising success. Here in the background appears again the specter of behavioristic adaptation, in this case strikingly like that evinced by the human species, whose dominant position with respect to food has been only mildly shaken by the recent manipulation of food supplies and the extension of our dietary deep into the realm of the ersatz. In spite of this similarity, the human line of ancestry suffered rapid evolution even before the advent of technology. Concerning the behavioristic attributes of the early anthropoids we remain ignorant, but they were obviously not of the fixed nature everywhere evident among the insects. This difference is clearly a factor of paramount importance in regulating the tempo of evolution.

Cases of greatly exaggerated "speed-up" are seen in many myrmecophilous and termitophilous insects whose habitat is re-



After Brues

TWO SMALL, ALMOST WINGLESS PHORID FLIES

THE FEMALES OF THESE AND NUMEROUS RELATED FORMS HAVE DEVELOPED MOST REMARKABLE BRISTLING ON THE BODY AND WINGS. *A, Ecitomyia spinosa; B, Xanionotum hystrix.*

stricted to the nests of ants and termites. Notable among these are certain minute flies of the family Phoridae that have partially or completely lost the wings in the female sex but have acquired in recompense most elaborate bristly ornamentations that place them at once among the most bizarre of all insects. Other members of this family, from what we know of them in the Oligocene fossil fauna, are, in contrast, reasonably stable. The same is true of other related living forms that occur in ant or termite nests but exhibit no unusual morphological changes resulting therefrom. Similar exuberance is notable in many tree-hoppers of the family Membracidae, where remarkable projections, excrescences, and other bric-a-brackery, developed on the prothorax, appear to be utterly useless and to have been called forth by nothing unusual in the environment. These tree-hoppers are perhaps the most conspicuous examples of this phenomenon, well known elsewhere among animals—although commonly associated with sex, as in the plumage of male birds or the contraptions designed partly therefrom by milliners as feminine adornment for the human species. Insects are only one of the groups of animals, or plants, for that matter, that have exhibited such varying rates of evolutionary change during their known history on earth.

Original

A CURIOSITY

A BRAZILIAN TREE-HOPPER, *Stylocentrus concolor* WITH LONG, SPINY PROJECTION ON THE PRONOTUM.

Original

A HAWAIIAN BEETLE

Proterhinus validus, ONE OF A LARGE NUMBER OF SPECIES FROM HAWAII, WHERE THIS GENUS HAS UNDERGONE EXCESSIVE SPECIATION.

They furnish some of the most outstanding examples yet brought to light, although so far our knowledge is painfully meager when compared with the finely delineated picture which paleontologists are able to draw of mammalian evolution, for example, among the Equidae.

Perhaps the most striking of all cases among insects, involving rapid evolution and very extensive speciation, are several genera of Hawaiian insects. One of these, *Sierola*, is a genus of Bethylid Hymenoptera including more than one hundred and seventy known species in these islands and a few others extending westward to Australia and China. Another, *Proterhinus*, of even greater extent, is the only known genus of a peculiar group, usually segregated as a monotypical family of beetles. The third is *Hyposmocoma*, a genus of moths with well over two hundred species in these islands. All are practically restricted to the Hawaiian Islands where they

Original

LUBBER GRASSHOPPER

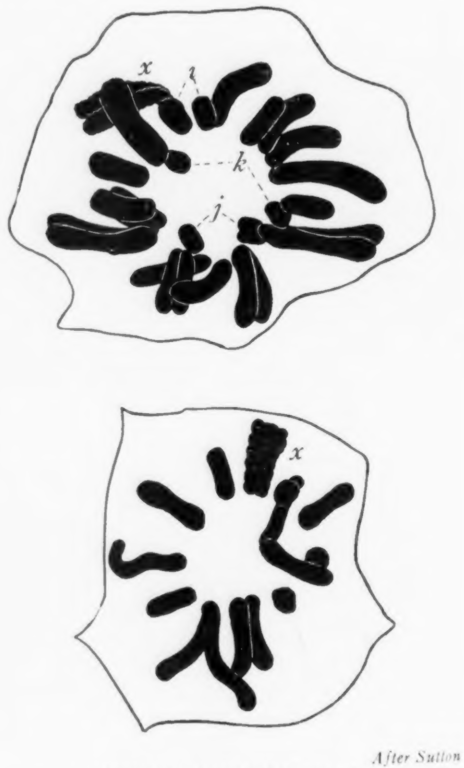
Brachystola magna, A LARGE NORTH AMERICAN GRASSHOPPER ON WHICH EARLY INVESTIGATIONS WERE MADE CONCERNING THE INDIVIDUALITY OF THE CHROMOSOMES.

have simply run wild on a prolonged, although geologically very brief, period of active and fertile speciation.

A necessary step in developing the unfolding panorama of genetics during the first decade of the present century was the demonstration of the individuality of the chromosomes. Coming just at the time of the belated rediscovery of Mendel's experimental work on plant hybrids, it made possible a much more ready and detailed study and understanding of the part played by the chromosomes as bearers of hereditary characters.

Insects formed the material for these cytological studies—in this case certain grasshoppers, chosen as particularly suitable for the purpose. The chromosomes of these insects are few in number, rather large, and each is of very characteristic size and configuration, which renders its recognition under the microscope a comparatively easy matter. So distinctive is the assortment of chromosomes in some species of these Orthoptera, that one ardent cytologist, not too well acquainted with the complexity of insect taxonomy, once advocated their use as the basis for a more rational classification of these and other insects. Obviously, if we might peer with sufficient ease and acuity into the ultramicroscopic constitution of the chromosomes, such a plan might conceivably be pushed to a satisfying conclusion. Recent studies of the salivary chromosomes of Drosophila and other Diptera certainly do show that this idea is not so fantastic as it appeared at the time, and, if such structural considerations ever invade the taxonomic field, it will be through the medium of the insects.

The biogenetic law regards the development of the individual animal as an immeasurably accelerated repetition of its evolutionary history, or, to use a catch phrase, it states that the ontogeny of the individual repeats the phylogeny of the race. This is primarily an embryological concept used with telling effect, especially by Haeckel and some of his contemporaries, to gain support for the principle of organic evolution.



After Sutton

INSECT CHROMOSOMES

TWO OF THE ORIGINAL DIAGRAMS PUBLISHED IN 1902 BY SUTTON, SHOWING THE INDIVIDUALITY OF THE CHROMOSOMES IN THE MALE GERM CELLS OF THE GRASSHOPPER *Brachystola magna*.

On account of the greatly modified manner in which their early development takes place, insects present little that falls in line with the expectations of the biogenetic law. Indeed, had they been chosen as materials, no such idea would ever have seen the light. In their early embryonic development most insects depart widely from the all-pervading pattern so generally characteristic of the majority of other animals. Still more conspicuous are the peculiarities of postembryonic growth which have resulted from the highly specialized type of metamorphosis they have developed, quite apart from any phylogenetic memories still lingering in the remains of their aboriginal germ plasm. Thus, the sequence of developmental changes in the holometabolous insects, comprising those with a complete metamorphosis, represents something acquired very recently, since the insects split off from other animals and were already differentiated from related groups of arthropods. The larval stage, which is the real innovation in this mode of development, represents, of course, an adolescent stage and must be regarded primarily as the orderly transition from the embryo to the sexually mature animal. However, it has become more than this in that it is really the interpolation of a stage which has undergone specializations that are truly its own, involving not only changed structures but also habits, habitats, and behavior. Under these circumstances the larva has been subjected to varied external influences which have led it to develop adaptations which do not appear to have visibly influenced imaginal structure.

It is quite true that the primary differentiation of larval types may be to some degree understood by the plausible assumption that they represent a sort of developmental fixation of either an earlier or a later embryonic stage, dependent upon the moment at which the embryo is born and becomes a free-living animal. Above and beyond such differences, the abundant and often profound and highly adaptive modifications of innumerable insect larvae obviously represent a phenomenon essentially identical with speciation but manifested only during adolescence. It is also essentially comparable to the sporadic occurrence of more than a single method of development in a single species, as noted particularly in certain Crustacea, to which the term "poecilogony" has been applied. But among animals other than insects this duplicity of evolutionary trends is no more than a freakish contingency. There are, however, several analogous phenomena concerned, and we must exercise care that heterogeneous concepts be not confused. For example, the now well-known races of the European malarial mosquito, *Anopheles maculipennis* differ most clearly from one another in the shape and coloring of the eggs. But these characters are neither embryonic nor juvenile since the egg shell is a structure produced directly by the adult mosquito. The term "epigenotype" has recently been proposed to include the transitory juvenile characteristics in development as exemplified in the growth and differentiation of the wing in Drosophila. Such stages cannot be regarded as primarily adaptive without reference to their end product and likewise do not fall into the category of independent juvenile modifications such as those outlined above.

The occurrence of natural variations among the individuals of animals and plants of the same species was one of the original principles on which the theory of natural selection was based. Later, just before the present century, the saltatory variations described by Darwin were recognized as a clearly different phenomenon from the constantly recurrent continuous variations presented by all bisexual animals, with the sole exception of polyembryonic siblings. Under their present designation of mutations they have become the *sine qua non* of

almost every genetical or phylogenetic inquiry dealing with any kind of organisms, plant or animal, and even among the still problematical viruses.

Insect mutations have received a major share of attention in experimental research, so far almost entirely with reference to anatomical structure. More recently, however, it has become evident that speciation among the insects is in many cases manifestly related to their instinctive processes. As is well known, the instinctive behavior of the members of this group is far more persistently fixed than that of other animals, particularly with reference to their food habits, and the far-reaching effects of mutations in instinct must be reckoned with as factors influencing speciation. As nearly as may be judged, pronounced mutations in instinct are of rare occurrence and, on the basis of rather fragmentary experimental study, appear to be quite exactly comparable to structural mutations. Quite aside from genetical studies, numerous cases of suddenly altered instincts have been observed where racial types have developed, associated with shifts in the selection of food by species of insects which restrict their diet to particular species of plants. The insects, therefore, have given clear evidence that mutations in habits may initiate changes leading to actual speciation, a supposition made earlier by Lloyd Morgan, but without convincing proof.

Just as has been observed when dealing with structure, both physiological and instinctive variations among insects may be recognized which fall into the category of continuous or recurrent variations. Totally unpremediated experiments of gigantic extent have been performed on some of our common insect pests in connection with the widespread use of arsenicals and other insecticidal poisons to protect horticultural crops from insect damage. Thus, as a result of continuous treatment over large areas, races have been selected having greatly increased resistance to the virulent poisons such as hydrocyanic acid, calcium sulphide (lime sulphur), and arsenicals which are used as sprays. From these observations it appears that there are extensive variations in resistance in many wild stocks, not hitherto suspected. Similar wide variations in winter hardiness which have been demonstrated in tropical flowering plants appear also to have their counterparts in insects and to be responsible, at least in part, for the extensions of range which have occurred on occasion among noxious insects; for example, the Mexican bean-bettle has shown itself quite able to withstand the rigorous winters of New England, although no such Spartan qualities are required in its native habitat. The importance of such peculiarities to the zoogeographer are obvious.

That the progress of modern biology has been greatly furthered through the medium of the insects cannot be questioned, but I do not doubt that others who have been sequestered in the company of worms, bacteria, protozoans, shellfish, or even of man himself may feel that their own charges should be placed in the ringside seats here reserved for the insects.

AEROLOGICAL ASPECTS OF THE BIKINI BOMB TEST

By A. A. CUMBERLEDGE
Captain, United States Navy

WITH the bursting of the atomic bombs over the ships at the Bikini Atoll anchorage in July, the gigantic experiment known as Operation Crossroads reached its climax. Designed primarily to test the effect of the atomic bomb on naval vessels, the Bikini tests were not thereby necessarily limited in their conclusions to this single objective. Indeed, it is conceivable that certain other data may prove eventually as significant and valuable in related research as those for which the tests were primarily prepared. The recording of scientific data in all fields of research obtained at Bikini will affect in all probability, through interpretation and use, the life of mankind profoundly.

Mark Twain's classic lament was refuted at Bikini. There everyone talked about weather, and even if they could not control it aerologists were on hand to predict, on the basis of reports garnered from many sources, the prevailing weather for the test days. A world waiting at the radio on these days was assured that the meteorologists had been right—the weather on both occasions was perfect. Admiral Blandy in a recent speech said:

> This weather feature was all-important. In fact the more I saw of my Task Force, the more I realized that I had nothing to worry about from them; the only thing that could throw us would be the weather. I felt fairly confident that my aerologists could predict it, but I wasn't sure they could control it. Looking back, I am almost willing to believe they did that.

OPERATION CROSSROADS

Under the direction of the Joint Chiefs of Staff, with the Army, Navy, and Manhattan District and various governmental agencies participating, 2 bombs were exploded at Bikini in July. The first bomb (Able Test) was exploded at a prearranged

Joint Army-Navy Task Force One Photo

THE FIRST BIKINI BOMB EXPLODES

height in the air. In the second, or Baker, Test it was planned originally to explode the atomic bomb on the surface of the water, but this specification was changed to permit explosion at a set point beneath the surface of the water.

Target. The target in each instance was a group of naval vessels anchored at specified positions so that accurate data on the effects of the explosion on ships at given distances from the explosion could be recorded. Upon these target vessels platforms were built to accommodate not only instruments to record the effects of the atomic bursts, but also various types of Army and Navy equipment that the services desired to test.

But the gathering of scientific data was not restricted to the surface area affected by the explosions. High above the target points, drones were sent after each explosion through the deadly radioactive cloud which rose like a geyser and mushroomed over the area, to collect radiological data, followed later by conventionally manned planes. Airplanes were also used to monitor and detect areas which, it was feared, had been contaminated by radioactive particles.

No glamorous figure of stage and screen ever faced a greater barrage of cameras than Operation Crossroads. Men delving into the epochal possibilities of atomic fission were careful that no photographic angle be omitted; from drones and piloted aircraft, surface operating and target ships, and Bikini itself, cameras recorded this moment in destiny.

Split-Second Accuracy. The entire experiment, vast in size and tremendous in implication, from its inception to its climax was necessarily complex. The gigantic undertaking of Task Force One commanded by Vice Admiral W. H. P. Blandy required not only the cooperation of 40,000 Army, Navy, and civilian personnel, the use of

Joint Army-Navy Task Force One Photo

HUGE CLOUD COLUMN

FOLLOWING THE EXPLOSION OF JULY 1, 1946.

more than 200 naval vessels and approximately 75 aircraft, but also the cooperation of almost all the military establishments in the Pacific Ocean area. The work of these thousands of men, as well as the expenditure of money and materials, had been so great and the collecting of data in the short time during and after the explosions had to be so swift and accurate that only a schedule in accordance with split-second timing would be effective. It is hard, therefore, to imagine a more dramatic concern for weather than there was in relation to the Bikini bomb tests. Practically every element could be guaranteed but the unpredictable whimsy of nature whereby winds can come and storms brew out of the far reaches of the equatorial Pacific.

The Importance of Weather. When the atomic bomb tests were postponed from May and June to July, public interest as well as the concern of Task Force One focused on the weather. The favorable weather anticipated by the original schedule

Joint Army-Navy Task Force One Photo

THE SECOND BIKINI BOMB EXPLODES

could not be counted upon during midsummer at a point in the equatorial areas where the winds of two hemispheres converge. This weather belt is subjected to extensive cloudiness, fickle winds, and torrential rains. The zone, called the equatorial front, moves north and south but lags behind the movement of the sun across the equator. Thus, generally, toward August the front reaches Bikini. This does not spell cloudy weather every day, but at such a time clear days in the northern Marshalls will be intermittent. The front on any given day may be a considerable distance either north or south of Bikini Atoll, but if all the positions are averaged the mean position lies across Bikini.

Thus it is clear that the change of schedule to July jeopardized to some extent, insofar as suitable weather was concerned, the successful accomplishment of the tests. Since, however, certain days might be ideal for the tests, the aerologists, their task complicated by the oscillations of the equatorial front, had to be prepared to advise the Task Force Commander when suitable weather conditions were expected.

METEOROLOGICAL REQUIREMENTS

Weather was important on several counts First, it was necessary to insure radiological safety of all personnel. It is hard to imagine anything more lethal than the radioactive remains of atomic fission. We are dealing with an all too possible nightmare when we consider the equivalent of tons of radium floating loose in the atmosphere in deadly concentrations. To guarantee that the tests would not be suicidal, it was necessary for aerologists to make sure that the winds at all levels up to the base of the stratosphere would be in such a direction as to carry the contaminated atmosphere away from personnel participating in the tests.

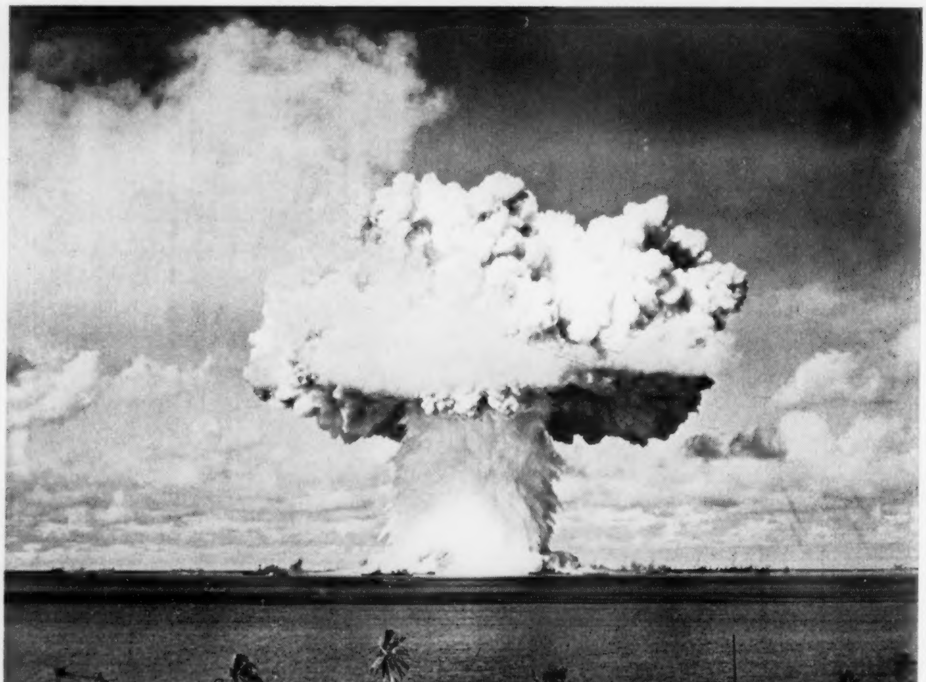
The Task Force Commander, Admiral Blandy, had the following to say about safety:

> If our manned planes were to pass through the cloud, which might happen after it had broken up or if part of the cloud dropped some of those fission products on one of the 150 naval vessels of the Task Force operating outside the lagoon, it might mean serious illness and even death to some of the 40,000 men participating in or observing the tests. So it was all-important that we know exactly what the winds were doing at all levels. You can see that our weather forecast for Able Day was not just a matter of "fair and warmer;" it was a matter of life and death.

Although the factor of safety was primary, there were still important considerations related to operational requirements. The weather had to be suitable for flight operations since certain data could only be collected if there were unrestricted aerial observations. All crews on aircraft had to be able to see the array of target ships, and, in the Able Test, from an altitude of 30,000 feet the bombardier of the B-29 carrying the bomb had to have an unrestricted view of the target. Successful photographic coverage, of course, was dependent upon clear weather. Although the critical altitude on Test Baker was lowered to 20,000 feet, an unrestricted view from even greater heights was desirable. In both tests, therefore, the meteorological requirements were equally stringent.

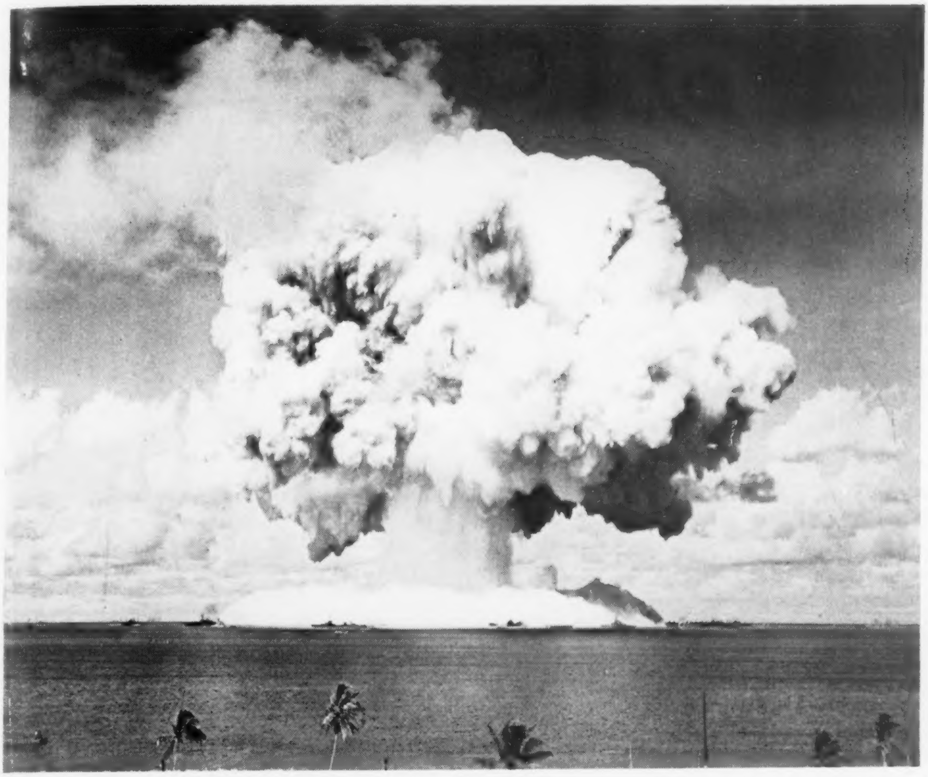
Out of these requirements came the decision that the tests could be run off only under these conditions:

1. All the winds up to 60,000 feet had to be from a safe direction.
2. The total amount of cloud below 30,000 feet on Test Able Day and 20,000 feet on Test Baker Day could not exceed three-tenths. If the cloud conditions were between three- and seven-tenths, it might be possible to accomplish certain tasks under local orientations of



Joint Army-Navy Task Force One Photo

THE LADY OF THE LAGOON



Joint Army-Navy Task Force One Phot

THE COLUMN OF WATER BEGINS TO FALL

> cloud, but on the whole that possibility would be in question. If the total cloud cover was seven-tenths or over, the operations under such conditions would involve serious loss of data.

Furthermore, time was of the essence. If accurate forecasts of the weather could not be predicted 24 to 36 hours in advance, the only alternative open to the Task Force Commander was to prepare to explode the bomb each day. The utter impracticality of this procedure is at once evident, for the complexity of Operation Crossroads, with its vast instrumentation, meant that once it had been set in motion it would have to be canceled before midnight of the same day in order not to waste the following day. In other words, the operating personnel required time to set and check instruments and to take personnel away from the target ships. It is obvious that to prepare for a test each day on the chance of ideal weather would mean that after 4 or 5 days the crews would be exhausted, and, if the tests were still delayed at the end of the period, complete rechecking of all instruments would be required.

Upper-wind forecasts had to be prepared at least 24 hours in advance in order to allow time for placing ships and aircraft bearing operational personnel in sectors where they could accomplish their missions and at the same time be free from radioactive contamination. If these forecasts were wrong, it would be easy to change the location of fast-moving aircraft, but to execute a similar maneuver for comparatively slow-moving ships would create a problem of such magnitude as to render it physically impossible. And, faced with the dreadful possibility of a sudden shift

in wind direction which would rain radioactive particles down on manned ships, aerologists had to formulate their plans and make decisions which would guarantee the Admiral information so that he might protect the fleet from such a danger.

Upper-Wind Studies. One of the first tasks confronting the aerologists assigned to the staff of Joint Task Force One was the preparation of elaborate and detailed studies of all available upper-wind data in the Marshall Islands area. Statistical studies indicated the maximum dispersion of radioactive cloud that could be expected at all levels and the probable frequencies of wind directions. In preparing operational plans for ships and aircraft and arranging for alternatives in event an emergency arose because of changed wind direction, these upper-wind studies were invaluable. The statistical studies were likewise important in determining the plans for insuring safety to personnel by determining the exact nature of the hazards which might be expected. Upper-wind data for the Bikini area were not available. Careful interpolation of wind data obtained at Eniwetok in 1945, together with scanty records from the southern Marshalls, produced information sufficient for preliminary planning. Then, as the operation progressed, it was possible to augment and modify the original studies on the basis of data received on the spot.

The available data revealed that the average distribution of winds in the Bikini area was easterly from the surface to 25,000 feet. Between 25,000 and 35,000 feet, the winds shifted into westerly quadrants and stayed westerly until the tropopause (about 55,000 feet) was reached. Above the tropopause, the wind direction was again easterly. Although this was true throughout the year, there was evidence that 25 percent of the time during July and 50 percent of the time during August winds from easterly quadrants existed at all levels from the surface to the stratosphere. On the basis of these percentages, the requirement was made initially that there be easterly winds from the surface to 60,000 feet, but this stipulation was relaxed as operating experience made it apparent that Task Force One could not afford to pass up a day with suitable cloud conditions because of stringent wind requirements. Moreover, it was found that various upper-wind combinations could be used with safety. In determining acceptable wind conditions, each case had to be decided in the light of the radiological hazards to ships, aircraft, and inhabited islands in the area.

Reporting Schedule. In the vicinity of the Marshall Islands, at Marcus, Wake, Eniwetok, Kwajalein and Tarawa, a network of Army and Navy weather stations was established, equipped with radar upper-wind recording instruments. Manned by specially trained personnel, including specialists from the United States Weather Bureau, these stations furnished information four times daily on wind conditions up to approximately 60,000 feet.

The network of island-based stations was augmented by ship stations in which aerological units were established for the purpose of making upper-air observations by radar. Observations from these units were scheduled every 3 hours, and just prior to and during the test periods, every 90 minutes. At first glance, it may seem that an excessive number of upper-air soundings were required, but we could not depend on less frequent reports in view of the fact that the very lives of personnel were dependent upon wind direction.

On the basis of upper-winds reports and the regular weather maps, daily forecasts of expected winds to the level of the stratosphere were prepared for the succeeding 36 hours. It was upon the basis of these forecasts that the sectors in which

ships and aircraft could safely operate were designated.

Weather forecasts were not based only upon reports from the network of island and ship weather stations in the Marshall Islands area. A far-flung network of reporting units covering the North Pacific insured adequate coverage. From China and Siberia to a line midway between Hawaii and the West Coast, and from the equator to the Aleutians, reports were received from the regular Fleet Weather Central broadcasts from Pearl Harbor and Guam.

A Fleet Weather Central is an aerological unit charged with furnishing weather information to the Fleet. The Weather Central not only collects reports, edits, compiles, and broadcasts weather data at specified times, it also analyzes, encodes, and furnishes weather maps to units too small to perform these functions. Let a storm or typhoon start its reeling course at sea, and the Fleet Weather Central immediately notifies all naval vessels, sends out warnings, locates the track of the storm, and estimates its intensity.

These Fleet Weather Centrals, developed just before the beginning of World War II, are an indispensable link in the weather chain. Without the Weather Centrals, it would be impossible to intercept a workable coverage of weather reports in time to prepare a forecast of any value. If weather forecasts are to be reliable, the aerologist must have an ample coverage of accurate weather reports and they must be received promptly; forecasting on the basis of local data is bound to prove unsatisfactory.

In the Marshall Islands area, Army and Navy weather stations were required to make more frequent reports than ordinarily required.

Because of Bikini's isolated position in the Pacific, it was impractical if not impossible to establish a sufficiently dense network of shore-based weather stations within the desired radius. The alternative of establishing ship bases was not wholly satisfactory in view of the time involved. Obviously, a ship can remain on station only a certain length of time and then must be relieved, so that additional ships must be provided to prevent lapses in receiving observations. On the basis of the number of ships involved, the personnel, the logistics, and overhaul problems, such an arrangement can only be justified on a long-time basis.

Weather Reconnaissance Aircraft. It was therefore advisable to depend largely upon weather reconnaissance aircraft—3 Army Air Force B-29's and 4 Navy PB4Y-2's—with trained weather personnel aboard. Equipped to gather weather data, these planes could be dispatched swiftly to any point. Radioing back their reports to base, these planes covered thousands of square miles of ocean areas. In addition to the two scheduled daily flights lasting 12 to 14 hours, these airplanes were called upon when special information was needed.

Illustrative of this special use is the procedure used on test days. On Able Day the weather planes were routed over Bikini Atoll. The first plane arrived about 0130 local time and immediately made contact with the U.S.S. *Mt. McKinley* over voice radio. After making an upper-air sounding over the lagoon and giving these data and a complete weather report to the ship, the plane then proceeded eastward on its assigned flight path. Additional planes arrived at 0330 and 0530 local time, each following the procedure of the first plane. On Baker Day the routine was altered so that all 3 planes arrived in the area at 0330. After an upper-air sounding had been made and reported by one of the planes, they were stationed at 1,500, 8,000, and 15,000 feet, respectively, at positions approximately 40 miles upwind from the target, and from these points aerological officers reported cloud move-

ments toward Bikini lagoon. Once the atomic bomb was exploded, they proceeded on their assigned flight. By using the planes in this way, it was possible to obtain meteorological information directly from the levels above and near the target area.

The technique of aerial weather reconnaissance developed during World War II was an outstanding contribution to the forecasting of weather for operations.

Weather Conferences. Once all information was collected, it had to be placed on maps, and analyses which included both surface and upper-air charts had to be made. Since this service required large numbers of trained personnel, it was necessary to establish a special Crossroads Weather Central at Kwajalein rather than on a ship, where restrictions of space and communications would be a problem. But this separation of the aerological unit from the U.S.S. *Mt. McKinley* did not mean that it was not an integral part of the operation, for the installation of a voice radio conference circuit established between the *Mt. McKinley* and Kwajalein made regular and special weather conferences possible.

Throughout the Task Force there were 75 aerological personnel, of whom over half were qualified aerological officers. This total does not include the personnel at the Marshall Islands weather stations or in the entire Pacific network. Although the figure may seem high, it proved to be the absolute minimum for efficient operation.

The formulation of a final official weather forecast for operation on the following day required the coordinated efforts of both the Staff Aerological Unit and the Crossroads Weather Central. Early in the morning, the unit on the *McKinley* and the Weather Central made weather forecasts for the next day upon the basis of the analyses of the 1,200 Greenwich civil time reports. These forecasts were the subject of the early morning weather conference, during which the Weather Central contributed necessary details of the upper-air analyses as well as information obtained from personal conversation with aerological officers aboard the reconnaissance plane. The Staff Aerological Unit supplied essential cloud data and trends obtained from local indications in the Bikini area. After a full discussion, the Staff Unit dictated the official forecast. This forecast, which was immediately distributed to all Task Group Commands, was used in preparing operational plans.

Each morning at 0830, the official weather forecast was presented in detail to the Task Force Commander and his operational staff. Following this briefing, the Admiral made a complete operational decision and the staff simulated actions to be taken on the actual test days. This procedure was of great value in training all aerological personnel.

In the late afternoon, another weather conference with the Weather Central was held and the morning forecast was modified if observations warranted it. If modifications were made, they were presented to the Task Force Command at 2200 local time and Task Group Commanders were notified.

The elements of each completed forecast included the amount (stated in tenths) of low, middle, and high clouds; base and top altitudes of the low clouds and the altitude of the other cloud layers; precipitation if expected; the wind direction and velocity of 5,000-foot increments from the surface to 60,000 feet; height of the tropopause; visibility, temperature, and relative humidity.

In view of the fact that only once during the entire period covering all the test and rehearsal days did an operation have to be canceled because of inaccurately predicted weather, it is clear that the fore-

casting at Bikini was effective. Further indications of the efficiency of the forecasting system can be gained from a summary of the weather forecasts for Able and Baker Days.

WEATHER FORECAST FOR ABLE DAY

The weather map for 1200 GCT on June 29 (2300 local time, June 29) indicated the presence of a widespread high-pressure cell, the center of which was located 600 miles north-northwest of Midway. This anticyclone was drifting slowly east-northeast toward the Gulf of Alaska, thereby causing a significant weakening of the surface pressure gradients in the Marshalls. An extensive low-pressure system was located 250 miles west of Guam. Although this low did not have the intensity of a severe storm or a typhoon, it was causing overcast skies and showers as far west as the Philippines and as far east as Truk. It was not expected that the low-pressure area would deepen or show much movement in the next 48 hours.

On the twenty-ninth a west-to-east trailing upper-air low-pressure trough passed the Bikini area and caused the development of a high-pressure ridge at altitudes above 20,000 feet. This passage of the upper-air trough, which was traced accurately through Eniwetok and Bikini, intensified and produced severe thunderstorms on the thirtieth in an area 400 to 500 miles directly east of Bikini. The development of the upper-air wedge subsequent to the passage of the trough caused the antitrades to flow from the northwest at altitudes above 20,000 feet. From soundings made by weather reconnaissance aircraft, there was also noted a dying out of the air at levels above 6,000 feet. This was correctly associated with a general subsidence and invasion of drier air caused by the upper-air high-pressure development. This factor eliminated the likelihood of a layer of middle clouds in the Bikini area. The equatorial front in the region of the Marshalls was located just south of Jaluit and north of Kusail and Ponape. The front was *not* expected to influence the weather conditions at Kwajalein or Bikini for the next 36 hours.

Upon the basis of these facts, the following forecast for the Bikini area for July 1, 1946, was prepared and presented to the Task Force Commander at 0830 local time June 30:

> Two- to three-tenths cumulus clouds with bases at 1,500 feet, tops at 5,000 feet. No middle clouds. About six-tenths of high cirrus clouds at altitudes above 30,000 feet. Total cloud cover below bombing altitude at target time two- to three-tenths. Winds aloft expected to be easterly 10 to 15 knots up to 15,000 feet, variable at 2 to 8 knots between 15–25,000 feet and northwesterly 25 to 35 knots above 25,000 feet.

The Task Force Command thereupon scheduled Able Day operation for July 1; time of bomb drop, 0830 local time.

During the day of June 30, the weather reconnaissance aircraft soundings showed significant increases of moisture at levels below 5,000 feet in the Bikini area, but this factor was expected to influence only the nocturnal convective cloud condition. The cloudiness would tend to reach a maximum near dawn and then rapidly diminish during the early forenoon. At the conference held at 2200 June 30, no change was made in the weather prediction announced in the morning. Between the hours of 0100 and 0600 local time on July 1, weather reconnaissance aircraft made continuous cloud observations and upper-air soundings in the Bikini area. Seven- to eight-tenths cumulus clouds, occasionally swollen to 13,000 feet and accompanied by frequent lightning with showers, were reported in the immediate vicinity of the lagoon. While this nocturnal convective activity had been anticipated, its intensity was significantly greater than expected. At 0500 local time on

July 1, another weather briefing was held, at which time the forecast of two- to three-tenths cloud coverage was reiterated. It was pointed out that the nocturnal cloudiness would tend to reach a maximum at dawn and from that time onward would diminish.

This prediction was substantiated by the command aircraft which was checking on weather conditions at the time, as well as by the Aerological Officer aboard the weather reconnaissance aircraft flying in the immediate vicinity of Bikini. Relying on this additional information, the Task Force Command directed the B-29 which was to drop the atomic bomb to take off from Kwajalein on the revised target time of 0900. After 0700, the cloudiness continued to diminish, and at 0830 the total amount of cloud was estimated at from two- to three-tenths. The forecast had proved accurate in all respects.

WEATHER FORECAST FOR BAKER DAY

The forecast for Baker Day was equally spectacular. Perhaps it was the more remarkable of the two forecasts, for it was made during a period of unsettled weather and heavy tropical rain. In the weather conference on the morning of July 23, it was pointed out that a typhoon was developing in the Marianas area and that a general synoptic situation was occurring similar to that which had produced favorable weather for the Able Day operation. Widespread subsidence was therefore expected east of the typhoon area. This optimism was somewhat premature because a surge of the trade winds from the south sent the equatorial front into the Bikini area during the night. Thunderstorms and heavy showers persisted throughout the Bikini area and surrounding quadrants.

While this deterioration of local weather prior to the morning conference of the twenty-fourth made the members of the Staff Aerological Unit apprehensive, they found no positive reason to modify the original favorable prediction for clearing weather on the twenty-fifth. It was predicted that the equatorial front would move northwest of Bikini and drier air would become dominant.

Thus the following forecast was presented to the Task Force Command:

> Weather forecast for Bikini area for 25 July 0800 to 1600 local time. Three- to four-tenths cumulus clouds, bases at 1,500 feet, tops mainly 3,000 to 8,000 feet, but isolated tops developing to 15,000 feet. Little or no middle clouds. Three- to four-tenths of high clouds near 32,000 feet. Total cloud cover below 20,000 feet three- to four-tenths. Winds aloft easterly 15 to 25 knots at all levels.

This favorable forecast was accompanied by certain reservations. The outlook certainly did not warrant complete confidence. The Task Force Command was advised that weather reports, particularly those relating to winds and the air reconnaissance reports, received during the day would indicate whether or not small amounts of clouds would prevail. Baker operation was thereupon scheduled for the following day, but with a reservation that a postponement might be made after the evening weather conference if the favorable forecast did not hold.

During the day the aircraft weather reconnaissance reports indicated that the frontal wave had definitely passed Bikini. Furthermore, although the conditions eastward were showery and unsettled, there was improvement in the southeast, and cumulonimbus clouds in the Bikini area were being sheared off above 20,000 feet by a northerly subsiding flow. By late afternoon, there was a decrease in convective activity resulting from this subsidence. At the 2200 weather conference, it was stated that the frontal wave would continue northwesterly and the equatorial front would stay north of Bikini.

The forecasted heights of the tops of low clouds were reduced to 8,000 feet. Therefore good weather would prevail.

All late information confirmed the forecast, and the Task Force Command ordered the test to go off on the schedule determined in the morning.

During the evening conference distant lightning played to the north of Bikini in the direction of the equatorial front. Radar observations revealed shower activity 30 miles north and several showers to the east and southeast. Since the winds were southeasterly, it was probable that one of the small showers would pass over the U.S.S. *Mt. McKinley* and that thereafter conditions would improve. A light shower proved this assumption correct.

Weather reconnaissance flights undertaken at 0300 local time showed that conditions were favorable for the operation. The upper-air radiosonde observation revealed an isothermal layer between 7,000 and 8,000 feet, with relatively dry air above which prevented clouds from developing to any extent. This forecast was verified by the fact that during the critical time for photography and flight operations, only two- to three-tenths of small cumulus clouds were present. Thus the forecast made during one of the worst days encountered at Bikini proved valid.

EXPLOSIONS AND EXISTING WEATHER CONDITIONS

Prior to the atomic bomb tests, there was widespread speculation as to the effect of these explosions upon existing weather conditions. Prophecies ranged from the formation of rain showers through violent thunderstorms and, in a few cases, even to the formation of a typhoon.

Basis of Forecasts. Forecasts of violent weather reactions were based primarily upon two major considerations. It was thought that the large amounts of moisture in the tropical air mass at Bikini, plus the large quantities of water expected to be evaporated from the water surface, would be extremely conducive to thunderstorm formation upon the release of the large amount of atomic energy into this mass. Second, it was believed that the high atmospheric concentration of ionized particles resulting from the atomic burst would serve as nuclei for condensation and thus be conducive to the formation of clouds and rainfall.

If the mechanism producing a thunderstorm is examined, it will be found that these storms require convection, or mechanical lifting, for at least several hours over relatively large areas as well as the proper vertical distribution of moisture. Convection, or lifting, of the air mass continues even after the full-fledged storm has developed. The atomic bomb is unable to produce convection of the sustained type. The bomb produces a sudden impact of energy, and convection ceases as quickly as the hot ball of gases cools on ascent and reaches its maximum altitude. The atomic explosion, therefore, consists of a violent, quick action over a relatively small area. A great deal of speculation centered on whether this sudden impulse might not precipitate thunderstorms if the atmosphere were just on the verge of instability. The answer to this question is that the release of energy is so sudden that the atmosphere is unable to rearrange itself to take advantage of the instability in the time allotted.

Any examination of the atmosphere will show that at all times there are suitable nuclei present for water vapor condensation. These nuclei are sufficient for cloud formation in all areas but particularly over ocean areas where very abundant hygroscope salt nuclei are present.

First Tests. In the New Mexico test, a thunderstorm preceded the atomic explosion. Without considering the sequence of events, this observation is not infrequently distorted to imply a genetic relationship. The fact that the storm occurred *before* the explosion proves that there was no connection between these events.

Many references have been made to rainstorms associated with, or resulting from, the atomic bombs dropped over Japan. These have been, in the main, speculatory and are without substantial meteorological basis. If rain showers did occur in Japan, it is conceivable that they were the result of convection caused by the widespread fires which sustained it for a long period of time after the explosion. This phenomenon has been noted over large forest fires and over burning European cities during the war.

Shortly after the atomic air burst on Able Day at Bikini, many small, light rain showers developed throughout the northern Marshalls. The clouds associated with these showers extended from 2,000 to approximately 6,000 feet. In the path of travel of the radioactive cloud, some measurements were made of radioactive rain. The amount of radioactivity was so small that it was of only academic interest. Some attempt has been made to associate this radioactive rain with the formation of the showers. The showers were, however, very widespread and were accounted for on the basis of the existing atmospheric conditions. The radioactive rain was a result of radioactive particles above the tops of the clouds falling into the rain cloud or of particles being present in the area where the cloud formed and, thence, falling out in the rain.

Inspection of ship and shore records in the Bikini area and pictures taken over the lagoon revealed that the only detectable changes which took place in the wind or atmospheric structure were the momentary effects of the blast and heat wave and the violent changes which took place in a rather limited area in the vicinity of the explosion. It is important to note that the cloud pattern over Bikini lagoon was undisturbed except at that point where the doughnut-shaped cloud formed around the explosion.

At the present time there are now two adequately documented cases of the inability of atomic air bursts to cause rainfall, the New Mexico test and the Bikini Test Able. In both instances, the thermodynamic and moisture structure of the atmosphere was properly staged for rainfall production. The mechanism for the release of energy in the form of rain showers or thunderstorms in each case was missing.

Cloud Chamber Effects. One of the most interesting phenomena noted in connection with the two atomic explosions at Bikini was the cloud chamber effects. Each explosion was accompanied by the formation of a dome-shaped cloud which later took the form of a doughnut as the top of the dome was disrupted by the resulting upward movement of the ball of hot gases in the first test and by the water column in the second test. This doughnut-shaped cloud extended from the surface to approximately 1,000 feet. The cloud effect can be attributed to rarefaction in the wake of the blast wave with the accompanying adiabatic cooling. The existing relative humidity was high enough so that the adiabatic cooling caused condensation.

In Test Able, the intense heat and the resultant ball of hot gases developed by the explosion created a large convective cloud similar in appearance to the cauliflower structure of the cloud of a thunderstorm. As the hot gases rose, there was constant cooling from the outside and the excessive moisture evaporated from the water surface began to condense. The result was the formation of a relatively narrow, towering cumulus cloud. The rate of ascent was very rapid, and in about 10 minutes the cloud reached a height of approximately 35,000 feet. As quickly as the cloud reached equilibrium with its surroundings (its maximum altitude), further convection was shut off. All further processes were concerned with the dissipation of the atomic cloud.

The identity of the cloud was maintained for about 50 minutes; then the existing

winds dispersed it into 3 main sections. The portion from the surface to about 15,000 feet moved to the west-northwest; the portion from 15,000 to 25,000 feet was diffused in all directions by the light and variable winds in that region; and the part above 25,000 feet drifted to the south-southwest. When the cloud was no longer visible, its trajectory was computed from the observed wind soundings and was shown ultimately to have taken a path at all levels to the northwest. It recurved in a large arc, flowed to the northeast, and passed over the vicinity of Wake Island 48 to 72 hours after burst time.

As the cloud passed upward through the freezing level at 19,000 feet, a characteristic false cirrus, or scarf, cloud formed and gave the appearance of cascading downward. Within 2 or 3 minutes, this false cirrus was enveloped by the rising warmer convective and turbulent currents and became indistinguishable.

Second Bikini Test. In connection with Test Baker, much interesting speculation was offered on the aerological effects. With the atomic bomb exploding beneath the surface of the water, would there be the same ball of fire as had been observed before? It was believed that a ball of fire, together with tremendous amounts of liquid water and water vapor, could be expected to result in a rain of spray and the formation of a convective cumulus cloud. If there was no ball of fire, the result would merely be the expulsion of of liquid water only into a plume of spray. Since the collision between tiny suspended cloud droplets, if any, and large falling water drops would remove the former, it was considered that no significant cloud could be formed by the simple injection of water into the air.

Actually, Test Baker produced a vigorous ball of hot gases with the attendant liquid water and vapor. Within seconds after the previously described cloud chamber effect, a column of water and spray was observed having a width of approximately 2,100 feet, topped by a water vapor cloud that rose to 8,000 or 9,000 feet within 3 minutes. This cloud subsequently settled down until its top was about 7,500 feet. At the same time clouds formed underneath an isothermal layer present in the atmosphere at about 6,000 to 7,000 feet. This cloud spread out to a diameter of about 6 miles. A rain of water spray continued to fall from the cloud layers for 15 to 20 minutes. The source of moisture for this rain came completely from the water ejected from the lagoon.

Effects of Local Weather. It can be said that no significant meteorological influence other than purely local cloud effects resulted from the Bikini tests Able and Baker. The evidence obtained also sheds light on the reverse of this problem, that is, whether it is possible to destroy certain destructive atmospheric phenomena of nature such as typhoons, hurricanes, and tornadoes by a sudden release of man-controlled energy. At present this possibility seems remote. It is logical to deduce that the limitation of available energy in the atomic bomb which prevents storm formation will also prevent storm destruction. The tremendous energies required over considerable periods of time to cope with natural phenomena are still not attainable in man-made explosions similar to the Bikini detonations. It may thus be concluded that a local rainstorm can neither be started nor dissipated by an atomic explosion, no matter how favorable atmosphere conditions may be. The forces exerted on the atmosphere by the atomic explosion will not appreciably affect the surrounding wind, temperature, or pressure pattern except momentarily and in the very immediate vicinity of the burst. Man has not yet reached the stage where he can compete with the forces of nature.

A CASE REPORT ON A HISTORY OF SCIENTIFIC IDEAS*

By DOROTHY STIMSON

Dean, Goucher College

PRESENT-DAY emphasis on the importance of science in civilization and its place in our culture is evident to anyone who reads educational publications like the Harvard Report and books and articles in the more popular categories, such as *Teacher in America*, by Jacques Barzun, or William Laurence's reports on science in the *New York Times*. College faculties are discussing these days how best some unifying, integrating force can be restored to college curricula to achieve a harmony like that in the days when theology was the capstone of learning. Nearly 40 years ago, however, Thorstein Veblen recognized such a harmonizing force when he wrote: "The growth of the scientific point of view begins further back than modern Christendom, and a record of its growth would be a record of human culture."

This paper is a report on the history of the scientific point of view that has actually been taught now for 25 years in a liberal arts college for women. It is an attempt to show the importance and the significance of the subject matter in the opinion and from the experience of the students themselves. And it is also a plea to scientists to welcome such courses in undergraduate colleges despite the fact that they may be taught by historians or philosophers who are not experts in science themselves. The historical method and approach reach many who would otherwise be deterred by their own unfamiliarity with technical terminology. It gives meaning to the sciences they may have had to study as part of their education and it helps to relate science to knowledge as a whole. It also re-enforces from an outside point of view the importance of the scientific work science students have been studying, leading them on to further work in the field or to further reading and study about it.

In 1922–23 the history of the scientific point of view was first given at Goucher College, Baltimore. Since then, with the exception of one year, it has been given every fall, including this past one. It is an elective in the Department of History offered to junior and senior students, all of whom have already had in college at least a year of laboratory science of one or more kinds. These students come from every major department in the college: music as well as biology; Latin, fine arts, philosophy, history, and economics as well as chemistry, physics, physiology, mathematics, and psychology. For the period of the fall term they give one-third of their working time to the demands of the course and in that time they trace the development of science and the sciences through the ages and through the civilizations of western Europe from primitive man to Pasteur.

They are guided in their study by a carefully prepared syllabus and by reading lists supplemented by their own detailed and intensive study of a man or an idea from each of two periods, that of the Greeks and that of the beginnings of modern science. Classroom talks and discussions help them to trace the thread of science through the maze of historical material of all kinds. Emphasis upon certain major documents like the Edwin Smith Surgical Papyrus,

* From an address before the Section on the History and Philosophy of Science, 113th Meeting, A.A.A.S., Boston, December 26–31, 1946.

the Hippocratic Oath, and Francis Bacon's dream of Salomon's House in his *New Atlantis* give them glimpses at firsthand of the long road science has traveled through the ages. Admittedly a rapid survey, avoidance of the curse of superficiality is attempted by insistence throughout the course upon its providing merely a framework or outline for reading, study, and thought for many years to come. The syllabus provides the skeleton of an idea, the development of science; the students' own prior information and all their reading and study contribute to filling out that skeleton into a vital, growing body of knowledge about science and its spirit. And that spirit is of major importance today.

How can such a course be taught? Its originator, after undergraduate courses in laboratory science as well as in the humanities, was trained in history under James Harvey Robinson and greatly stimulated by his course at Columbia University in the "History of the Intellectual Class of Western Europe." She earned her own graduate degree by tracing the gradual acceptance through the centuries of the Copernican theory of the universe and found it was not a long step from an interest in the history of an astronomical theory to a major interest in the progress of science itself: What helped it advance, what hindered it? What sciences first developed, and how far were the men of science great because of, or in spite of, the era in which they did their work? Finally a long year of work in London on science in the seventeenth century under the guidance of Dr. Charles Singer and of Professor Wolf, together with constant revision and further reading—all this has reinforced and strengthened the teaching of the professor in charge. So also have the successive classes who throughout these years have made their contributions to her training by their points of view, their questions, and their suggestions. And it is to these students that the director of this course turned for an answer to the questions: Was the course worth while? And, if so, in what ways? What did it mean to the students themselves as distinct from what the instructor thought it should mean?

During these 25 years 445 young women have completed the course satisfactorily and have since graduated from college. Some 30 more are still in college. To those who have graduated a two-page questionnaire was sent, requesting their help in preparation for this address. Sixteen of the questionnaires were returned for lack of the right address, 2 came back unanswered, but 64 percent of those queried troubled to reply, many of them with amplified statements and accompanying letters. The replies came from members of every class from 1923 to 1946 and from almost every major department, providing a wide cross section of interests and activities. Almost half of those replying, 134, had majored in college in some science; the other group of replies, 139 of them, was divided between the 38 who had majored in the arts, languages, and literature and the 101 who had majored in philosophy and the social studies. All of them were asked what the significance of the course had been to them as part of their undergraduate curriculum and what specific use they had made of bibliographies, facts, and ideas in their later work. Had it consciously affected their intellectual life after college (Table 1)?

To judge by the item most frequently checked (238 times by 273 replying) and also most frequently double-checked (65 times), as the one of most significant value for all groups, this was to develop an interest in the history of ideas. For the older alumnae this, they say, has meant wider horizons, a more tolerant point of view, and greater patience with man's slow progress. That ideas have a history of their own has turned the attention of some alumnae to tracing specific ideas in other fields, not just in science—in fact, one calls

it "potential dynamite"! Another wrote that it made her "more conscious of [her] heritage and of the rise and fall of ideas and hence of the progresses and retrogressions of civilization as a whole."

The next largest total number of checks made by all three groups together emphasized the sense of historical perspective gained through the study of the scientific developments down through the ages together with a widened knowledge of notable people. "It gave me a feeling of the orderly progress of events." To one it gave the "sweep" of history. To another it took science "out of a vacuum" and "related it to its background, social, economic, cultural." Or, as another phrased it: "It took science out of the laboratory and made its story fascinating and real." It aroused interest in "scientists as men and products of a certain age, heritage, and culture." It made another aware of the "interrelationships of science with politics, art, and every phase of life." In short, science became "a part of human life, and of the development of man."

TABLE 1

Analysis of Replies to Questionnaire on Significance of Course in History of Scientific Point of View

Number of Times the Following Statements Were Checked by Alumnae Classified According to Their Undergraduate Majors

Statements Checked by 273 Alumnae	Alumnae Divided According to Undergraduate Majors			Total
	Science 134	Phil. & Soc. Studies—101	Lang., Lit. & the Arts—38	
Developed interest in the history of ideas	120 (35)	84 (25)	34 (5)	238 (65)
Developed historical perspective	96 (21)	79 (17)	30 (10)	205 (48)
Widened knowledge of notable people	99 (6)	76 (6)	29 (1)	204 (13)
Increased appreciation of scientific method	81 (5)	79 (11)	24 (1)	184 (17)
Opened possibilities for later reading and study	88 (17)	66 (6)	29 (9)	183 (32)
Widened range of reading done	79 (4)	68 (4)	23 (1)	170 (9)
Related various fields of the curriculum to each other	63 (6)	58 (12)	28 (9)	149 (27)
Synthesized science courses	68 (10)	23 (1)	4 (1)	95 (12)
Increased understanding of laboratory procedures	11 (1)	9 (0)	0 (0)	20 (1)
Led to election of more science or mathematics courses	4 (0)	2 (0)	5 (0)	11 (0)

(Figures in parentheses indicate the number of times this item was double-checked to indicate that it was considered the most significant result of the course.)

For the small group of majors in the arts, languages, and literature, the development of an interest in the history of ideas or of a historical perspective was hardly more im-

portant than the fact that for most of them it integrated the curriculum, "relating science, literature, the arts, as parts of a whole, not as specially growing fields of endeavor." And for many of the younger alumnae, majors of the social studies, that too was for them as important a result as the development of historical perspective or even the increased appreciation of the scientific method, to both of which their group as a whole gave second place. Their answers blend into each other, though, as shown by their use of the terms "synthesis" and "correlation" of knowledge.

Curiously enough, while more than half of the science and of the arts majors said they had gained in the appreciation of the scientific method, to three-quarters of the students of the social studies that was a major result of the course. "Ways of thinking," "broad point of view," and "liberal ideas" are not of course definitions of the scientific method, but apparently in the minds of these alumnae they are linked with that idea. Specifically, some have tried to apply the scientific method in teaching illiterate soldiers, in working with engineer husbands, in pursuing graduate study. It is a theme running through many of the answers: "It made me *think*." It developed "understanding of the importance of methods of observation and of scientific honesty as applied to social studies also." It was concerned with "challenging mental processes and their logical evolution." "I do not remember facts or details [this from a graduate of 1929] but I know that certain ways of thinking and reasoning and a broad outlook as well as a certain tolerance (to the extent that I possess them) can be traced in large measure to this course."

Increased awareness of the history of ideas and of historical perspective, an appreciation of the scientific method in other fields than just in the laboratory, an integration and correlation of the fields of knowledge beyond the somewhat artificial barriers of college departments—these are not all the values of such a course, though they are of marked significance to these women. The large majority count themselves enriched by acquaintance in their setting with great men whose names they had hardly been aware of before and whose ideas, some of them two thousand years old, startle them by their modernity. A former major in psychology was amazed to discover for herself that Empedocles, for instance, had contributed to her field; and all are impressed by the scientific objectivity of the Surgical Papyrus, the history of which reaches back into the third millennium before Christ. The medieval period came alive to a brilliant English student who wrote that before it had always seemed empty of interest to her. Most of all, they emphasize that it is science as a continuing activity that impresses them. One man drops defeated, but sooner or later another picks up his idea and carries it on.

The influence of the course does not stop when the classes are ended. For a few it has led to the election of more courses in science even in those students' senior year. A graduate student at Yale writes of her enjoyment as an auditor in a seminar on the history of medicine, another that for 15 years now astronomy has been her hobby. For many it has led to the reading of books they otherwise would not have been interested in. Teachers and librarians have made frequent use of the bibliographies and the outlines provided, to judge by their comments. A doctor's secretary reads for her own pleasure the historical material advertisers send her employer, and many speak of their interest in recent historical books and articles about science. As a stimulus to further reading in the field the course has contributed its share.

Incidentally, the course has also had a social value for these young women quite unexpected by the instructor. They write that it has contributed to dinner-table con-

versations, USO gatherings, and even to greater companionship in marriage because they had a more understanding appreciation of the scientific work being discussed than they otherwise would have had. One young woman remarked that she had elected the course because she was engaged to a medical student, that she knew nothing whatever about his field, and she thought that reading about the history of medicine would give her more comprehension of, and a better preparation for, her future life as a doctor's wife. Others have written of going with their husbands to scientific meetings and of hearing one scientist belittle the social studies and another point out the need for historical training for scientific people. One who graduated twenty years ago writes: "From my long acquaintance with scientists, I think historians are more appreciative of scientists than scientists are of history." And husbands are quoted as having wished that they had had such a course in their undergraduate days.

Some young women, fired by the subject, have asked about the possibility of making a career for themselves in the history of science. One, a chemistry major while in college, has done so and is now managing editor of a journal on the history of medicine while at the same time working in the history of American medicine. Others have started graduate work in the history of medicine until marriage carried them away to other activities. For most the answer to the question of the career has had to be: Keep it as your interest, your hobby; you cannot earn your living on graduation by work specifically in this field as yet. Recently, however, a possible opening has appeared through the developing work of the museums of trade, industry, and science and their desire to secure young people who can explain exhibits to school children and who can write about them accurately and directly for publication. This may well prove to be a hopeful opening for more than the one or two who have found their way into it already.

At best, a course like this in the history of the scientific point of view can only be the opening of a door and a glimpse of the long vistas of rooms and galleries stretching on endlessly, waiting to be explored. As an introduction it provides a frame of reference. Logically, it should be followed forthwith by a detailed history of the biological or of the physical sciences, according to the student's interest—a detailed and technical history that would place the emphasis on modern developments in those sciences and would therefore have to be taught by historically-minded scientists, experts in those fields. Modern developments are far too technical as well as too numerous to be crowded into an already overcrowded survey, and they need to be taught by one who can speak with authority in the science itself. Such an arrangement was in operation at the University of London in 1930. Professor Wolf planned for his graduate students in the history of science to meet together for the first half of the year to survey the historical development of science down to 1800 or thereabouts. Then the class divided according to its preference, and during the second half of the year specialists in the two major divisions of science traced modern developments in their respective fields.

In an undergraduate college, as at Goucher, the same plan can be carried out on a small scale. A professor of chemistry has led his senior students in a history of chemistry. A professor of physiology has done the same in her field for her seniors, and for years a professor of biology has been dealing with theories of evolution and an astronomer with descriptive astronomy, set in their respective historical backgrounds.

Science majors in particular, of course, express the desire for more recent and more

technical material, but in the same breath they add that there would not be time for it, and even for them, as one expressed it, the course had made "lab work real."

Should such a survey be taught by a historian or by a scientist? Almost unanimously the science majors and the non-science ones chorus: By a historian. They prefer the different point of view, which they characterize as a broader one, freer from the technicalities of the sciences. A few said it did not matter as long as the person was a good teacher. But most stated they feared the stress a scientist might give to his particular interest as a possible restriction upon the historical perspective and the breadth of view which the historian of ideas can use in relating science as a whole with history, philosophy, literature, and religion. Technical details they can get elsewhere. What they appreciate is seeing the science of their choice correlated with other sciences and brought into relation with the general history of civilization. Parallels between the historical method and the scientific method bring greater appreciation of the distinctive values of both and of their importance in society today.

An older graduate writes that this was

> the only course pertaining to the sciences in my whole college career [and she had had to take a number] that I did not feel was being given in a language completely foreign to me; it gave me sufficient confidence in my understanding of the scientific method that I attained my M.A. from professors who lay stress on sociology being a science, and I can be of some help to my husband, a chemical engineer, because I can follow his line of professional thought, at least in respect to principles and generalizations.

What, in summary, do these comments and others like them indicate? What virtues has a history of the scientific point of view for women whether they are specializing in science or in something else? Only one of the 64 percent who answered said it had been of little or no use to her. For most it has made the era in which they live richer, more understandable, more alive, less provincial, and more dynamic. It has helped to break down artificial barriers and to unify science with other aspects of knowledge. Science for them is less esoteric, more significant, because they know something of the human struggles and failures attending its development, as well as the successes. Science for them is no longer chemistry or physics or mathematics, of concern only to those who have a special taste for laboratory work. It has become a significant part of knowledge as a whole, the influence of which permeates modern life and thought more thoroughly than even the science majors themselves had realized. They have discovered that, while great scientific discoveries have spurred on further scientific advances, they have also affected philosophy, literature, religion, and the course of history itself as well as being in their turn fundamentally affected by these same forces. And in their own thinking they have gained an appreciation of the scientist's methods of work till they no longer smile at seeing as a definition of science, "the process which makes knowledge." They, too, have had a glimpse of the meaning of the passionate search for truth.

The historical approach to science richly rewards its students, whether they are laboratory workers or not. Scientists would do well to welcome into the education of all students, not just of those in their own fields, courses similar to the one reported on in this paper; for the advancement of science even in this scientific age depends in large measure on the popular understanding of its principles and its methods. Popular support can help; popular prejudice can also cripple. Scientists need not fear the lack of expertness in their own particular science by the well-trained historian or

philosopher who attempts such a course. Students are shrewd. They discriminate between technical matters, about which they themselves may perhaps enlighten their instructor, and the breadth of outlook, the different point of view, the fresh presentation of names familiar in science in their historical setting as part of a culture and of an age hitherto not considered of importance to them in the mid-twentieth century. They can and do turn to their science professors for further technical enlightenment, which is as it should be; but those same professors, specialists in their various sciences and absorbed in contemporary developments, oftentimes in that absorption fail to realize how abstruse to the student, how difficult, and how complex their subject is. Yet that subject when viewed historically takes on new interest and reality when one has some idea of its dramatic history of failure and success, its interrelations with the ages in which its growth has been favored or checked, its incorporation into itself of the ideas of men of all ages without regard to their nationality or race. From such a study the student returns to her laboratory with a new appreciation of the complex processes confronting her, for she has had a glimpse of their long evolution. For her they have become *real*.

More than ever, civilization today needs not only the experts but a general public trained to appreciate scientific methods and the scientific approach to truth. People need to apply such methods and thinking to their own living and to value at its true worth the scientist's passion for truth. Teachers, librarians, mothers of families, writers, social workers—all testify to the values these ideas have had for them and to the stimulus to their intellectual life that the history of science provided. Would that all college faculties provided such courses.

The preservation of human liberty is paramount in world society in our time. The struggle to achieve and maintain it, viewed historically through the ages by following one major aspect of it, the development of scientific thought, brings reality and unity to a student's thought and work. For this struggle transcends all boundary lines, whether in the curriculum or on a map, and gives background for the comprehension of some, at least, of the factors comprising that paramount issue, human liberty.

VARIED APPROACHES TO NATURE

By LEWIS G. WESTGATE

Department of Geology, Ohio Wesleyan University

To him who in the love of Nature holds
Communion with her visible forms, she speaks
A various language.

NATURE'S message is an individual one: it is not the same to Darwin, John Muir, Winslow Homer, or Wordsworth. The various approaches to Nature find their justification in meeting essential human needs. They are not to be arranged in a hierarchy of ascending values; each has its own peculiar service to render. The scientist cannot say to the artist, "I have no need of thee;" or, again, the mystic to the scientist, "I have no need of thee." What follows is an attempt to point out the human values in the differing approaches of the scientist, the nature lover, the artist, and the poet, or mystic.

THE approach of the scientist is primarily intellectual. Its motive is curiosity. The child's inquiry, How is it made or how does it go? is still valid for the man of science. Nature is multitudinous, chaotic; the scientist is concerned with the order behind the apparent disorder. He observes, classifies, experiments—and meditates. In the end he has knowledge.

The great growth of science has taken place since 1500. In that time it has given us a new world and a new method and spirit.

This new world is radically different from the tight little world of the Middle Ages. Astronomy today looks out into infinite space, star on star, galaxy on galaxy. The earth is but a minor planet circling about an ordinary star, our sun, which is off-center in one of millions of known nebulae. The geologist looks back on an earth history of some 2,000 million years and counts on a future measured in millions. More important, the biologist views man as an animal among animals, as sprung from Nature and an integral part of Nature. For the first time man sees himself in perspective, gets a sense of his place in the totality of things, and is able to judge his present tendencies and future prospects. He finds himself a part of a great ongoing process, each stage of which is the culmination of all that has gone before and contains the seeds of all that is to come later. The key word is evolution.

In this new world the scientist increasingly finds order behind multiplicity and confusion. Early man peopled his world with spirits, mostly hostile, and lived in constant fear. In the thinking of the scientist there is no room for the intrusion of outside agencies into Nature. Neither devil nor angel has a look-in. Everything has its cause. When that is once understood fear goes, and superstition. If we can learn Nature's ways and are willing to adjust ourselves to them, we find her dependable, our friend.

The great contribution of science to the thought of the present is not so much its new knowledge, important as that is, but its method and spirit. Its method is, in fact, nothing other than that which we use every day in finding a lost cat or what is wrong with a stalled automobile. The procedure is simple: There is a problem, a proposed solution or hypothesis, and verification, which gives us knowledge. The difference lies in degree; in the extreme care which the scientist takes to avoid all error, inexactness, and personal bias. It is the very opposite of wishful thinking, which is wishing, not thinking. This procedure is

the only way we have of getting knowledge, is applicable in all fields where knowledge is possible, and the area in which it is applied is being steadily widened. It is this respect for fact, this spirit of unbiased devotion to truth, that is the great contribution of science to intellectual and moral life.

The world of modern science is quite unlike the world which the common man thinks he sees. It sometimes seems that the scientist's approach to Nature is a departure from Nature. The different sciences get away from daily experience in varying degrees, physics furthest. The so-called observational sciences—botany, zoology, geology, anthropology—still maintain touch wi h the common world. But for the physicist, it seems that the nearer he gets to "reality," the further he gets from actuality. From moving bodies he abstracts mass and motion and with these, from Galileo through Newton to the present day, he has been building up a splendid mechanical system which ties together sun, planet, and falling apple and is found to stretch out through infinite space. But it leaves out those qualities—color, form, etc.—which are of more interest to most of us as the source of immediate enjoyment. Subatomic physics carries us still further from everyday appearance. "The external world of physics has become a world of shadows," says Eddington. "One has to go out and knock on wood or rock to assure himself that there is anything to this solid earth." Let us be thankful that he leaves us the wood and rock to knock on! Shakespeare may have foreseen modern physics when he made Prospero say:

The cloud-capped towers, the gorgeous palaces,
The solemn temples, the great globe itself,
Yea, all which we inherit, shall dissolve,
And, like this insubstantial pageant faded,
Leave not a wrack behind.

Every dog has his day, and today in science is the day of mathematical physics. Yet, after all, the acrobatics of protons and electrons are not what most concern us. To leave them for the ordinary face of Nature is like coming out of the damp darkness of a mine shaft into the warm sunshine. It is likely that we are too much enslaved to the mathematical sciences, that it is the sciences of life which will have most to tell us; that chemistry and physics are only preliminary to biology. They have flourished earlier because their problems are simpler and easier.

THE nature lover's approach is direct; sensuous and emotional rather than severely intellectual. He is concerned with form and color, with touch, sound, and smell. He delights in the sheer breath of an October afternoon, in the odors of the pines and of the rain-soaked forest floor. His ear is attuned to the roar of the surf or to the gentle murmur of the wind through the trees. His eye glories in the blue of the sea or sky or distant mountains and does not ignore the shifting grays of the overcast heaven. It is the beauty of Nature and its influence on the human spirit that draws the nature lover, not mere knowledge; certainly not any use he can make of it in ordinary everyday affairs. Nature's beauty is primary, a free gift to man, not to be explained by any philosophy, but accepted with filial piety.

Byron felt it when he wrote:

There is a pleasure in the pathless woods,
There is a rapture on the lonely shore,
There is society, where none intrudes,
By the deep Sea, and music in its roar.

Wordsworth, writing of his boyhood experience of Nature, has expressed the point of view with finality:

For Nature then
To me was all in all.
The sounding cataract
Haunted me like a passion: the tall rock,
The mountain, and the deep and gloomy wood,
Their colors and their forms, were then to me
An appetite; a feeling and a love,

That had no need of a remoter charm,
By thought supplied, nor any interest
Unborrowed from the eye.

No better incarnation of the spirit of the lover of Nature can be found than in the American Muir or the English Hudson. Muir, a Wisconsin farmer, Scotch-born and university-educated, finally arrived in California at the age of thirty. From then on he was Muir of the high Sierras. For weeks at a time he tramped the high mountain country, alone, with the lightest equipment, never armed. Hunting was for him "the murder business," the very opposite of the sympathetic love for, and appreciation of, animal life. His primary interest was in plant life, especially the trees, and in the glaciers and their former courses; but he cared for every aspect of outdoor life: birds, streams, storms, the Indians, everything except civilized man. It would be pleasant to quote extensively from Muir's writings; two passages must suffice. The first is from *The Mountains of California:*

I chose a camping ground on the brink of one of the lakes where a thicket of Hemlock Spruce sheltered me from the night wind. Then after making a tin-cupful of tea, I sat by my campfire reflecting on the grandeur and significance of the glacial records I had seen. As the night advanced the mighty rock walls of my mountain mansion seemed to come nearer, while the starry sky in glorious brightness stretched across like a ceiling from wall to wall, and fitted closely down into all the spiky irregularities of the summits. Then, after a long fire-side rest and a glance at my note-book, I cut a few leafy branches for a bed, and fell into the clear death-like sleep of the tired mountaineer.

The second is from a letter to a tired and conventionally pious schoolteacher:

Do not, I pray you, destroy your health. The Lord understands his business and has plenty of tools, and does not require overexertion of any kind.

I wish you could come here and rest a year in the simple unmingled love fountains of God. You would return with fresh truth gathered and absorbed from pines and waters and deep singing winds. You say that good men are "nearer to the heart of God than are woods and fields, rocks and waters." Such distinctions and measurements seem strange to me. Rocks and waters, etc., are words of God and so are men. We all flow from one fountain soul.

Muir was to a degree a mystic, as I take it all lovers are. A reviewer of the recently published journals of Muir writes: "The philosophical naturalists of today have drifted away from the course John Muir was following. . . . John Muir is out of step with the times, or perhaps the times are out of step with John Muir." To be out of step with the present times may be an asset and not a liability. It may mean only that Muir is closer in step with the Eternal. Those who have stood hushed and alone at sundown will understand.

The nature lover's approach to Nature appeals to more of us than does any other. It requires less specialized and technical preparation than that of the scientist. It is neither necessary nor advisable to move in on all Nature. Many doors open to her domain: the love of birds, flowers, and gardening; of forest, desert, and mountain; of sky and cloud. Some answer one call, some another. None are excluded. But to get on intimate terms with Nature, to get the highest pleasure from that intimacy, is a long, happy, and enduring quest. Like human friendship, it must be won. It means being with Nature and studying her ways through the years. It is an experience open to all; no barrier of race, religion, or age intervenes. The sky, the fields, the mountains, the human face, are there for rich and poor alike.

THE painter is the see-er, he whose trained eye is sensitive to the forms and colors, lights and darks, of Nature. If we limit the discussion to landscape painting, it is for convenience only; what is true of the open country is equally true of man and the

man-shaped aspects of Nature. The play of light and color on city streets, in our homes, on human face and hair, we miss as easily as, perhaps more easily than, the features of the out-of-doors. Just as the ear of the trained musician responds to slight differences that the ear of the untrained man does not distinguish, so the painter through his long training notices form, color, and meaning that are hidden from those who have not attended to such things. It is the function of the artist to catch this and to express it for the rest of us.

Here is a marine painting by Waugh, the Provincetown artist who died in 1941. It has sea, sky, cloud, and rocky shore; wind and light and color. A strong, cold, onshore wind is driving in immense, deep-blue, white-capped waves, which break in a wild whirl of opalescent water and spray on the granite ledges in the foreground. The evening sun reddens cloud, spray, and rock. No human figure, no work of man, shows. Waugh has caught the very life and strength of the ocean. He has caught something more; the spirit of eternity, of the never-ending clash of the elemental forces of Nature. So it has been since God said, "Let the waters under the heavens be gathered unto one place, and let dry land appear." Throughout the earth's history, for some two billion years, with no human eye to see it, the slanting sunlight evening by evening has touched to redness similar scenes along all shores. It may be that after man's course is run and all evidence of his occupancy has disappeared that same scene will be enacted about all the borders of the continents. Ocean—sky—land—these are the signs of infinity. Waugh has caught not only the spirit of the ocean, he has caught its eternity.

Waugh writes of his own work:

> I spend part of each year studying the sea. I both paint it and watch it carefully, and the latter method of studying I am sure is invaluable. In that way I fix certain forms clearly in my memory and learn the why and the how of the grand old ocean . . . . If you really love Nature she will love and teach you.

As to the aims of his art, the painter may be allowed to speak for himself:

> The chief mission of the artist is to reveal that portion of nature's riches which he has discovered, to those who would not otherwise have suspected their presence. He serves as a translator and interpreter of nature to those who cannot understand her language (Millet).

> If we can give a man a canvas that will take him away from his desk and lead him into the field and make him feel what we feel in the presence of beauty, we have done something good. In our art this is what we strive for (Innes).

> The Louvre is a good book to consult, but it is only an intermediary. The diversity of the scene of nature is the real prodigious study to be undertaken . . . . The Louvre is a book where we can learn to read. But we should not be content to keep to the formulae of our illustrious predecessors. Let us leave them so as to study beautiful Nature and search to express it, according to our personal temperament. Time and reflection greatly modify vision, and at last comprehension comes (Cezanne).

To see and, seeing, to feel—for the approach of the artist is primarily emotional and not intellectual—and to express that which in turn will enable others to see and feel is the function of the painter.

It should go without saying, though it does not, that he who as artist pretends to reveal Nature to us through the medium of painting should master his craft. A stammering utterance does not help to get any message across, whether in prose, poetry, or painting. Nor are we in this connection concerned with the need of any cooped-up artist to relieve himself of his boiling emotions or passions; that is self-revelation and not interpretation of Nature. Some of the vagaries of recent art may be of interest as studies in psychology, perhaps abnormal psychology, but are of little help to one who wants a clearer insight into Nature.

There is, finally, the mystic's approach to Nature. Nature is alive; we can hold communion with her. Wordsworth's poetry is the best-known expression of this belief, especially the "Prelude" and the "Lines on Tintern Abbey." In the latter he writes:

> I have learned
> To look on nature, not as in the hour
> Of thoughtless youth: but hearing oftentimes
> The still sad music of humanity.
> And I have felt
> A presence that disturbs me with the joy
> Of elevated thoughts; a sense sublime
> Of something far more deeply interfused,
> Whose dwelling is the light of setting suns,
> And the round ocean, and the living air,
> And the blue sky, and in the mind of man;
> A motion and a spirit that impels
> All thinking things, all objects of all thought,
> And runs through all things.

Others will not have it this way. John C. Van Dyke writes:

> Nor is nature, as some would have us think, a sympathetic friend of mankind, endowed with semi-human emotions. Mountains do not "frown," trees do not "weep," nor do skies "smile." Indeed, as far as any sympathy with mankind is concerned, "the last of thy brothers might vanish from the face of the earth, and not a needle of the pine branches would perish" (Van Dyke, John C. *Nature for its Own Sake.* Scribners).

Why may not both be right, each possessing a partial insight into the doings of mysterious Nature? The quiet of a summer afternoon may speak peace, yet at that moment on another continent great armies may be at grips and men be slaughtered by the hundred thousand. Apparently Nature does not care, God does not care. Indeed this apparent indifference makes difficult any belief in a God who is concerned with the fall of a sparrow. In the desert one knows that missing the water hole means death. If the traveler on the glacier slips into a crevasse, the ice will close on him remorselessly. Van Dyke seems to be right.

Yet that is not the whole truth. The late Professor Winchester, discussing this very matter of Wordsworth's mysticism, puts it as follows:

> We all know that the common face of nature may sometimes have an effect upon our emotions like a soothing word or a noble deed. When Wordsworth says of a distant mountain peak that it sends
>
> Its own deep quiet to restore our hearts,
>
> or bids the river
>
> Glide, fair stream, forever glide,
> Thy quiet soul on all bestowing,
>
> it is not a fancy that he utters, but a fact. How it may be, perhaps we cannot tell; but the fact is undeniable. And more than that we know. In our moments of truest intuition we are sure that the fact of that influence implies some deep affinities of being. It is absurd to say that quartz can generate quietude of soul or that H_2O can calm the mind. What is it but spirit that can stir the spirit within us, that can suggest deep meanings to our intelligence or inspire to lofty and tender emotion? This belief may not admit of any very explicit statement in terms, because, like all our deepest convictions, it is half emotion; but it is a belief in which philosophy, poetry and religion are at one. And if you question its warrant you will at least find no better evidence for all our most profound convictions (Winchester, C. T. *Wordsworth, How to Know Him.* Bobbs-Merrill).

The validity of the mystical attitude toward Nature is not to be settled by argument. It is a matter of individual experience, where all the evidence is from within. It is partly a matter of temperament. In any one person it varies with differing mood and circumstance. In the quiet of evening, as the sun sinks to rest through golden bars of cloud, a strange and indescribable feeling of confidence in the beauty and goodness of the world comes over one. Is Nature, is God, speaking? Each must decide for himself. He who can may enter by this door the holy of holies of Nature.

The different approaches to Nature are not mutually exclusive; individual men can and do come to Nature by more than one

route. The approach of the scientist is not solely intellectual. He may feel intensely the beauty of the order of swinging planets, of the marvelous adaptations within the bodies of organisms, and of the organisms themselves to their environment; and he is usually, as was Darwin, far ahead of the average cultured man in his appreciation of scenery. Again, the painter and the lover of Nature will see more if they avail themselves of at least the elements of some of the sciences. An artist is expected to base his painting of the human face and figure on an accurate knowledge of anatomy. If he is a landscape painter he cannot appreciate scenery to the full extent without an understanding of the rock formations and of the forces which have carved them into their present shape. Muir did not appreciate the high Sierras less because he was a close student of their forests and glaciers. Nature is a world of color, of light and shade, of light broken, reflected, refracted, echoing endlessly back and forth. One sees more in the cloud-flecked sky of midday or in the banded colors of sunset if he has some knowledge of the physics of light. One does not have access to Nature if he comes with an empty mind. The more one brings, the more he will get.

Each of the approaches we have been considering satisfies definite human interests and needs. They are a free gift to men; and like good literature, friendship, and religion, which are also free gifts, they come only to those who meet certain conditions. They are not to be passively accepted, but actively won.

PROSPECT AND RETROSPECT: A DREAM OF MAN

By Almon Barbour

Back to primeval beginnings
When the earth was a blazing fragment
And the noonday sun was brighter;
Back when the ice moved down from the poles—
I saw myself one with man from the beginning,
Seeing him, knowing all his ways
With animals, plants, stones, stars.

Down the forgotten ages, I saw myself
Tracing his strange and bloody ways:
In the hanging bough in the forest,
Upon the rain-drenched cliffside,
Across the far-lying desert;
Tracing his strange and bloody ways
In every corner, in all the far places,
In all the long ages since the beginning.

One with him down the forgotten years,
Knowing his ways, his songs, his poems,
Thinking his thoughts of God and Evil,
Knowing his dreams of heaven and hell;
One with him, knowing his ancient loves,
Adoring his painted saints, his idols,
Feeling perennial fears and lusts;
Knowing the beat of his heart
Through the generations pulsing
Down all the years from the beginning.

Then I saw myself, an apprentice,
Go with him into the endless seasons;
I saw all man upon his star
Go marching into the endless years.
One with him from the beginning
And now and forever, I heard at last
His voice, trembling with hope and fear,
Interrogate the sphinx:
O ancient earth,
O animal of long hope—do we
With pain of laboring love go marching
Into the hills, or are we lost
Upon this widening, endless plain?
Do we labor now toward the light,
Or do we spin, in vain,
Wild circles in this deepening night?

ON LIFE AS A SEPARATE ENTITY

By THOMSON KING

Baltimore, Maryland

EVER since man has been able to think of matters beyond his purely physical needs and to express and record his thoughts, he has reasoned, speculated, talked, written, and debated with his fellows about the nature of life. There have been many theories and beliefs, but practically all of them can be assigned to the one or the other of two general schools which we will call "Mechanistic" and "Vitalistic." As our knowledge of ourselves and our environment has increased and become more accurate, the outlines of the two great divisions have become more clearly defined and understood. It is doubtful, however, whether we are closer to a generally accepted decision as to which is the true, or even the more probable, answer to one of our most interesting questions.

My object, and I hope justification, for the following elementary discussion of a well-worn subject is a form of approach which may be new, and perhaps interesting, to some readers. This will consist of avoiding religious and metaphysical concepts and confining evidence and argument to a simple but fundamental question, the answer to which may, I believe, be found in our present knowledge and our capacity to interpret that knowledge. The one important question will be presented in its simplest and most general terms, in such manner and form that it can be considered and judged very much as any question about the nature of the physical world is considered and decided.

We can hardly hope to demonstrate a rigorous proof of a broad general question in the same sense as a simple geometrical theorem. Perhaps if we state two theorems, one of which must contain the correct answer to our question, and then examine and weigh the evidence afforded by the present state of our knowledge, the evidence will indicate, and our reason will accept, a clear-cut decision as to which of the two opposed theorems has the greater probability of being true.

The word "probability" is not to be taken lightly. Most of the decisions and beliefs of intelligent people are based upon probability. If I were asked to state something of which I am absolutely certain, I should say, "I am sure that the next ten bridge hands dealt to me will not each contain thirteen spades." Yet I cannot prove it will not happen; my certainty is based on probability. Many of the laws of physics and nearly all of thermodynamics are of this nature; they are statistical, based entirely upon probability; their acceptance implies the assumption that excessively improbable events have not and will not occur. The same ideas and principles apply in biology. Few things can be proved beyond the shadow of a doubt, and indeed it is not necessary that they should be.

The mechanists hold that all phenomena associated with life can be entirely accounted for and explained in terms of matter and energy, and nothing else. They believe that at some time in the distant past, conditions were such that certain chemical and physical processes started, exactly as inorganic reactions are brought about, by combinations of matter under suitable conditions. The continued reaction of matter and energy, and nothing more, has produced, developed, and sustained all the activity and phenomena that are associated with life. Mechanists never admit that anything more is necessary to begin life in a

lifeless world or to maintain it in all its unique and various manifestations when once started.

The vitalists believe that life is something entirely separate, distinct, and different from matter and energy. It is always associated with and observed by means of matter and energy. We cannot observe it except in combination with them, just as we can observe matter only by means of energy, but the vitalists hold that its unique development and phenomena are due to matter and energy plus something else that is neither matter nor energy, nor a combination of the two, but a distinct and separate entity. Some vitalists have identified life with the soul or with consciousness. Certain philosophers have believed the latter to be the only reality—the *cogito ergo sum* of Descartes. All religions have been founded by vitalists; most of them have taught that something about life was immortal. They usually conceded a beginning but denied an end.

We can best reach our objective of the simplest and most general question as to the nature of life and the most probable answer by refraining from further talk of mechanists and vitalists. I will attempt to be scientific in method without being technical in language. Above all, I will endeavor to avoid what Hogben calls "the pitiful failure of introspective philosophy which resides in the finality of its answers." This can best be done by keeping clear of all religious and metaphysical concepts and arguments, which have too often led to vague, barren, and undisciplined discussion. I do not believe they are necessary and I know they are dangerous when it is desired to confine attention to one clear-cut, simple question. We will limit ourselves to the evidence of our senses and our instruments, which are always extensions, refinements, or amplifications of our senses. We will try to interpret that evidence in the light of reason and probability.

Before stating the question, it is necessary to say what I mean by several of the terms I must use. Definitions will be brief, for we are dealing with fundamental concepts and we know that true fundamentals can only be defined in terms of themselves.

By "entity" we mean something having reality in fact, which is separate and unique in itself. It may have many parts, qualities, and aspects, but it is not a part, quality, or aspect of anything else, except for the possibility explained in the next paragraph.

"Matter" and "energy" have their usual scientific meanings. It is to be clearly understood that under certain conditions they are mutually convertible. Einstein has shown that one gram of matter is the equivalent of C^2 ergs of energy, where C is the velocity of light in centimeters per second. We now believe the sum total of the matter and energy in the universe is and, as far as we can know, always has been a constant. Possibly they are two forms of one greater entity; but with the present state of our knowledge it will be simpler and more convenient to regard them as separate entities.

By "universe" we mean the full extent of what we call space and everything contained therein. It is a four-dimensional continuum: it has extension in three spatial directions and in time. From any given point we have an east-west, a north-south, an up-down, and a before-and-after. For the purpose of our discussion, it is immaterial whether the universe is finite or infinite in time and space, for whatever it may be we are going to stay inside.

The expression "in the universe" is meant to exclude from our discussion anything capable of existing outside the universe. A creator obviously must have existed before and outside of anything he created, and any question of creation is irrelevant and unnecessary to the discussion of our question.

I can now state my question in the form of a brief theorem, or hypothesis, and what seems to me to be its only possible alternate:

A. There are two fundamental entities in the universe: *matter* and *energy*. All phenomena are due to these two entities, separately or in combination.

B. There are three fundamental entities in the universe: *matter*, *energy*, and *life*. All phenomena are due to these three entities, separately or in combination.

Before considering the evidence for A and B, we must first be sure that these are the only hypotheses that can be made. Someone may say magnetism is a unique phenomenon of certain states of matter, and gravitation a phenomenon of all matter, and propose them as fourth and fifth entities. I think we now know enough to see that the theory will not hold water or even hold together.

There is a great deal we do not know about gravitation and magnetism, particularly as to how they act at a distance; but we do know essential facts that I think will dispose of the question. All our evidence indicates that gravitation and magnetism are properties that matter has always possessed. They did not appear at a particular era in the earth's history nor, so far as we know, have they changed or developed. Since life appeared upon this planet and began to leave its record in the rocks, its forms and phenomena have changed greatly. Indeed change, growth, and development are among the most important characteristics that have led us to consider whether life is or is not a separate entity. We can account for and explain the phenomena of gravitation and magnetism in terms of matter and energy and nothing else. I think we cannot escape the conclusion that they are properties of the entity matter.

I cannot think of any other phenomenon that can show a better claim to being due to a fourth entity. I must therefore believe the two hypotheses cover the entire field. What A asserts is denied by B. It is obvious they cannot both be true; therefore, one or the other contains the truth about life. It cannot tell us anything of the *whys*, *wheres*, *whens*, or *hows* we should like to know; it does give a general but positive answer to the first great *what*.

The only other objection to our hypotheses would seem to be the contention that matter and energy, and perhaps life, are but aspects or forms of one all-embracing entity. This indeed may be possible, but it is beyond the limits of this discussion and probably beyond the grasp of our present knowledge. By definition we are to consider matter and energy as separate entities, and then to attempt to decide whether life is also a separate and unique entity in the same sense.

I think it is self-evident that the behavior of matter, energy, and living things is governed by natural laws. Whether we believe in hypothesis A or hypothesis B we certainly do not believe in unnatural laws. The word "supernatural" also seems to me to be utterly meaningless except as a measure of our ignorance. All events in the universe are natural, and they are governed by laws. Events are no less natural because we do not understand the laws that govern them.

In weighing the evidence for and against hypotheses A and B, we must proceed exactly as we would in deciding any other question with regard to the nature of the physical world. The study of life by scientific methods is quite young, and there is much that we do not understand. But we may be sure that our best chance of increasing our understanding is by a rigorous application of the scientific method that has given us all our present knowledge of the universe and the laws that govern it: observation, experiment, organization of data, and the application of reason to the data. We seek knowledge, and the field of science

and scientific method is coextensive with the field of knowledge.

We believe a brick has certain qualities because of the direct evidence of our senses of sight and touch. We believe in gravitation because, though we cannot see it, we can see and feel its effects. We believe in electrons and radio waves because of the evidence of our instruments. We are sure X-rays are of the same nature as light but of shorter wave length because the evidence convinces us that this hypothesis is more probable than the alternative statement, that they are not of the same nature. We believe that oxygen and iron are unique elements rather than the alternative hypothesis, that they are not unique but only combinations of other elements, because the evidence of our senses, supplemented by our instruments, when considered by our reason indicates that no combination of other elements can produce the qualities and effects that are associated with oxygen and iron.

If it can be shown that our senses observe and our reason accepts phenomena that cannot be explained by any known property of energy or matter, or by any imaginable combination of the two, we must assume and accept the existence of a third entity in the universe. Hypothesis A falls and B remains. If this cannot be done, A stands and B can be forgotten.

THE EVIDENCE

The properties of matter are inertial, gravitational, electric, magnetic, chemical, and a general group that we shall call physical (shape, hardness, density, etc.). Those of energy are inertial, gravitational, and the capacity for doing work, producing change, vibration, frequency, and movement.

The phenomena of life are growth according to a predetermined complex plan, metabolism, reproduction, evolution of species, a limited time of occupancy in a particular body, inherited habit or instinct, a tendency to variation between generations, and, in the higher forms, consciousness, memory, emotion, reason, and other phenomena of the mind.

It is to the phenomena of living things that we must look for evidence to confirm or refute hypothesis A. Some of the phenomena I have listed are so closely associated that they cannot be discussed separately or in strict sequence. It is best to begin by recognizing and stating one rather obvious but essential fact.

So far as I know, with one possible exception, all phenomena of life are associated with matter. The bodies of all living things are composed of matter, and they live by employing energy. It seems to be characteristic of life to appropriate, use, wear out, and abandon aggregations of matter. Since our senses depend entirely upon matter and energy for receiving sensations and information with regard to the physical world, they can tell us only of phenomena involving matter and energy. If more than matter and energy are necessary to explain any phenomena, our sense cannot directly inform us of the fact; it must be deduced by study and reason from the evidence of our senses or instruments.

The facts just cited have always exerted a profound influence on all discussion of the subject. For many investigators, they have seemed sufficient proof that life must be a rather specialized and peculiar activity of matter and energy and nothing more. Today we can see much further into the problem than a few years ago. In the light of present knowledge, I do not think the fact that the phenomena of life are associated with and observed by means of matter and energy proves anything one way or the other. Until a comparatively short time ago, water was thought to be a single, simple substance. The belief was founded upon lack of knowledge and power of analysis, chemical and mental. For the same reasons men once thought the earth was

flat. With the benefit of more evidence from observation and closer reasoning we now believe it to be an oblate spheroid.

I am aware of and respect the opinion of many eminent biologists, probably a majority of all biologists, that is epitomized in the following quotation:

> There seems to be no escape from the conclusion that the vital properties of organisms are due to the condition in which their material exists for the time, and that they are not the manifestations of the presence and action of a separate entity in the way of a so-called vital principle.

This is a very positive statement of belief in our hypothesis A, but I find it less than convincing. To accept it, I must believe that all the phenomena of life are due to the condition and arrangement of the substance called protoplasm. Protoplasm is indeed a complex and remarkable material made up of a number of the more plentiful elements, but I think the biologists are placing on it more than it can bear. Its condition and arrangement must account for the fact that one tiny cell carries the plan and implements the life cycle of an oak tree, another of a mosquito; it must cause the oyster to build his limestone shell, the bird to inherit the ability to build a nest; it must account for metabolism, which is not found in any other arrangement of matter; finally, it must account for thoughts and all the multitudinous activities of the mind.

The scope of this discussion does not permit any lengthy excursion into biology, but I must cite two more quotations from biologists which seem to me very significant and enlightening. "There is no such thing as dead protoplasm." Do we not have here acknowledgment of something that is not to be found in matter and energy? Biology seems to say there can be no life without protoplasm and no protoplasm without life—the old chicken-and-egg dilemma. But if the activities of protoplasm are due to matter and energy only, what does the statement that there is no such thing as dead protoplasm mean? Why can we not have protoplasm without life? To me, it seems to imply that the origin and activity of living things are due to a combination of matter and energy with, or under the direction of, something else.

The distinction between living and nonliving aggregations of matter is of an entirely different order than that which separates organic and inorganic. So far as I know, all the phenomena of nonliving organic bodies can be accounted for by hypothesis A. We need no special laws or assumptions to explain their behavior with regard to entropy or anything else. So long as I am alive, the laws that are adequate for nonliving bodies fail to predict or explain all my bodily, and to a greater degree my mental, phenomena. As soon as I am dead, although the atoms of my body are the same, no particular or special concepts are necessary—simple organic chemistry will predict and explain all that can happen to that curious aggregation of organic compounds. The laws peculiar to living things are additive, not contradictory, to laws of matter and energy.

Other biologists, in particular the geneticists, are somewhat more specific and specialized in their opinions. They say that it is only necessary to postulate the assembly and combination of material in the primeval sea to produce an autocatalytic substance with a tendency to mutation, to account for the origin and development of life. A typical statement is: "These considerations lead us to regard the gene as the essential basis of life: a gene, or gene substance—i.e., a mutable, specifically autocatalytic substance—contains the potentiality of all the forms and phenomena of life." In this sweeping assertion "gene substance" has replaced the more general protoplasm as the essence and explanation of life. But is the explanation valid? Is it based on facts or on faith? We know that genes are the

carriers and determinants of heredity, that they are found in all living cells. The mechanists are endowing the matter of which they are composed with qualities and potentialities that, so far as I can see, are not indicated by the known properties of nonliving matter. Even the words "mutable" and "autocatalytic" cannot confer upon matter alone the ability to reproduce successive generations of organisms of a predetermined and complex pattern with inherited instincts and abilities.

The eminent physicist and mathematician Erwin Schrödinger says:

> The arrangement of atoms in the most vital parts of an organism and the interplay of these arrangements differ in a fundamental way from all those arrangements of atoms which physicists and chemists have hitherto made the object of their experiments and theoretical research, ... Whether we find it astonishing or whether we find it plausible that a small but highly organized group of atoms be capable of acting in this manner, the situation is unprecedented. It is unknown anywhere else except in living things.

He also finds the all-important characteristic of life is its ability to feed upon what he calls "negative entropy." For those who understand the meaning of entropy this is interesting. By these statements Schrödinger does not mean that life processes are not subject to physical laws. What he does mean and states clearly is that they are unique in requiring different and additional laws to interpret them as compared with nonliving matter. Neils Bohr says: "The existence of life is an elementary inexplicable fact, which must be taken as a starting point in biology." Sir J. Arthur Thomson said: "Life is a unique kind of activity, requiring concepts transcending those of mechanism—and mind is independent."

So the chemist, the biologist, and the physicist, each in his own way and according to his point of view, finds an essential difference between living and nonliving matter and accounts for it by some unique arrangement of matter or behavior of energy in an organism which the same matter and energy does not possess before it enters the organism or after its death.

The mechanists have offered no proof or demonstration that a living organism can originate from nonliving matter to operate, develop, and survive through matter and energy, and nothing else. They speculate that it is possible.

We are able to synthesize many products of living things in the laboratory. We know the elements in protoplasm and can make shrewd guesses as to those in genes. We know a great deal about the conditions under which the simpler and more primitive life processes operate. We can keep life processes going by artificial arrangements, under unnatural conditions and environment, when they have been started by living things. We have so far been unable to create a living particle with or without a "tendency to mutation" from nonliving material.

I cannot imagine any combination of substances and conditions existing in the ancient seas that could not be reproduced in a modern laboratory. I find it hard to believe that such a complex organism as protoplasm, or "gene substance," was assembled, combined, and activated by any chance combination occurring in the primeval sea. The probability against its creation, multiplication, and survival, if there was nothing in it but matter and energy, seems to me to be of the same order as that against the ten all-spade bridge hands.

To sum up, we have found no proof that the simplest living organism can be produced without resort to some existing living thing. Furthermore, it seems that even if this were possible, it is very improbable that it could have resulted from chance combinations of matter and energy.

From this brief reference to origin, we must now pass to behavior and continue our

search for evidence. All living things grow. There is also what may be called growth of nonliving things, as in snowflakes or other crystals. Is this nonliving growth the same, or is it essentially different from the growth always associated with life? If life is a separate entity, we should expect the latter to be the case. Failure to find essential differences would support hypothesis A.

Both living and nonliving growth require that suitable material be available in a suitable environment; it is hard to imagine how it could be otherwise. Here the identity ends and the difference begins. Consider snowflakes and infusoria. The former begin to grow without the presence or agency of other snowflakes. Infusoria start only from living infusoria or from very similar living organisms. If I am asked how the first living organism started, I must reply that I do not know and that I cannot see that it has any bearing on the question. I do know that when life appeared a new kind of growth began and has continued.

The growth of crystals and, so far as I know, of all nonliving things involves only the addition of more of the same material to the structure. The growth of living things always involves the assimilation of material, its use to build the structure and to supply energy, and the elimination of used material, an entirely different process. A living organism cannot grow without the elimination of waste products.

As snowflakes grow, there will be many different patterns, depending upon conditions in the medium in which they are growing, but in general all will have a hexagonal symmetry. The infusoria will grow according to predetermined patterns similar to, but not always identical with, the preceding generation. The conditions of the medium may vary within reasonable limits, but the growth of living things sticks to the pattern it inherits from preceding life. If conditions vary too widely, the snowflakes may melt and the infusoria may die. In the first case, the material might, under suitable conditions, be reconstructed into new snowflakes, but the material of the dead infusoria cannot be reconstructed into new infusoria except by the action of life.

A copper crystal may grow in a solution and, if conditions are kept favorable, may become quite large, but it is always a copper crystal. We cannot imagine its growing old and dying; we can, however, imagine its remaining unchanged for millions of years—in fact, for as long as we please. The smallest copper crystal is like the largest, except for size, but the big tree is not like the small seed from which it grew, nor does the moth resemble the caterpillar. In a suitable medium of inorganic materials we can cause the growth of structures that look very much like mushrooms or other living things. We can make a drop of oil or chloroform act like an amoeba: it will perform movements that closely resemble those of the animal and even imitate some of its life processes, such as digestion and extrusion, but none of these mechanisms is alive any more than an adding machine is alive because it can add if properly manipulated.

I think the great difference between nonliving and living growth is that the former is determined and controlled by the materials supplied, the medium in which, and the conditions under which, it occurs; the case is quite different for living things.

It is not the matter that enters a living body nor the conditions under which it lives that determine in kind how it shall grow and what it shall be. These follow a plan inherited from preceding life. The arrangement of material is determined and directed by something that is not to be found in lifeless matter. An excellent illustration of this principle impressed me as a boy. There was in our yard a pear tree that had been

grafted upon quince stock. Quince shoots had sprung from below the graft. The sap that came from the roots to build and nourish the central pear tree and the quince branches was identical, the weather and environment were the same; yet one grew as a pear and produced pears, the other as a quince and produced quinces. I have never been able to find an explanation for this and similar phenomena in the behavior of nonliving matter.

Life possesses the power to cause matter to grow according to a predetermined plan, which even in the lower forms is amazingly complex and elaborate. The tiny fertilized egg carries in itself the plans and specifications of an oyster, a mouse, or a man. Conditions and environment can kill them or change their growth in degree but not in kind.

Reproduction and metabolism are so closely associated with growth that it is hard to speak of one without involving the other; the same may be said of evolution. I do not think we can find any phenomenon of nonliving matter that even remotely resembles the phenomena that we observe in reproduction, metabolism, and the evolution of individuals and species; nor can we find in the properties of matter and energy anything that will satisfactorily account for them without the addition or interposition of something that is not found in any known property of matter or energy.

In all living things we have the reproduction of successive generations of similar but not identical units. There seem to be two general methods: by division and sexual. In the first, one makes two; in the second, two make one or more. Chemical processes where life is not present, if carried out with the same elements or compounds under like conditions, produce like products. In the life cycle the ever-present tendency to variation and mutation, with the survival of the fittest and natural selection, produces profound changes in species.

Metabolism is also unique in living things in that it can be described as the purposive assimilation of matter in a living body. It begins and ends with life. There is nothing unique in the chemical and physical processes involved. Many so-called organic substances are being synthesized in the laboratory; sugar can be formed in a suitable solution by the action of sunlight on carbon dioxide. In living things metabolism is obviously designed and directed to effect the survival, reproduction, and multiplication of the plant or animal. Have we ever found, or can we imagine, anything in matter or energy that would be concerned with the survival and reproduction of a particular configuration or arrangement of matter?

The same question might be asked about reproduction, which has given life its power of survival. The duration of life in an individual body is very short—perhaps 3,000 years in a redwood tree is the longest—but its duration in a species may outlast mountain ranges. It has survived on this planet for a billion years and, barring very improbable events, seems destined to continue here for many times that long.

The attributes of life I have so far discussed and what I have had to say about them are such self-evident matters that it may seem superfluous to have referred to them. Many other phenomena and examples deriving from the properties of life in its lower forms will occur to the reader. These could be discussed at great length. My only excuse for even the brief space I have given to stating and suggesting well-known matters is that they must be considered in any review of the evidence. They all have a very direct and important bearing upon the question before us. If neither matter nor energy possesses in itself or in combination the power to produce these phenomena, without the addition of something that is not to be found in matter or energy, hypothesis A cannot be true.

We still have to say something about the evidence that may be derived from the phenomena of the mind, which are exhibited by the higher forms of life in addition to the more universal properties just discussed. There are also several less apparent, more subtle, matters that it may be interesting to refer to very briefly.

Life, whatever it may be, evidently adds to the matter-energy combination the power to observe and remember, to think, to convert thought into action, to communicate observations and thoughts, to have, and to be influenced by, emotions. This enumeration is both overlapping and incomplete but will serve our purpose. These activities must be accounted for, either as being due to the reaction of energy upon certain peculiar arrangements of matter or upon a combination of matter and energy with something that is not in, nor a property of, matter or energy. We can undoubtedly do wonderful things with matter and energy, but our question is: Are matter and energy alone doing these things with us? Personally, I find it very hard to imagine that matter and energy and nothing else are making me write this article. It is even harder, in fact, impossible, for me to imagine that our ability to think, or even the more common phenomena of life, are the result of, and developed from, chance combinations of matter and energy.

It has been said that men and all living things are machines. This is true; they are all more or less complex mechanisms built of matter and using energy, designed to perform the functions associated with life. They all work by chemical and physical processes. When the living machine is wrecked or wears out, so that these activities can no longer be carried on, life disappears and we have nonliving matter. The machine is still there, but it is like an electric motor with the switch open. The motor, however, may be made active again by closing the switch. The matter in the dead animal or plant may be appropriated by other living things and live again in their bodies, but we have so far found no way to bring life back to the original body after it has really left.

We find what may be truly called machines in the nonliving world. Tornadoes and cyclones are heat engines on a vast scale. We can build machines ourselves to do wonderful things: to rule 30,000 lines per inch for a diffraction grating, to add, to multiply, and to solve differential equations; but we know very well that our machines are not alive. If hypothesis A is true, the living machines, including ourselves, consist of nothing but matter and energy. The ability to produce and account for all they do, feel, or think must be found in matter and energy, separately or in combination. All this is simple and obvious, but it leads to some interesting and important conclusions.

It appears that if we believe in hypothesis A we must also believe in some things that to me seem highly improbable. A quotation from *Some Consequences of Materialism*, by J. B. S. Haldane, will provide a good example: "If a super biochemist made a working model of me, atom for atom, this robot would on a materialistic view have all my memories. This may be the case, but if so, I do not see how knowledge is possible."

This robot that Haldane suggests is a very interesting creature. He is absolutely identical with Haldane, so far as matter and energy are concerned. Hypothesis A says he would be alive, that he would possess and could use all Haldane's knowledge, personality, experience, and reasoning power, as well as all other functions of life. B says, No, unless he has something else that is not matter or energy, he is not Haldane and he is not alive.

Even if we apply this idea to a far simpler organism than a distinguished biochemist, say, to the tiny fertilized egg of a fish or insect, the argument seems to me to be equally powerful against those who believe

that all the phenomena of life can be accounted for as due to a rather special arrangement of carbon compounds in a colloidal state and nothing else. To agree with them I must believe that the position and arrangement of the atoms in the egg will cause it to grow through all the phases of the life cycle of the fish or insect. Because of this arrangement of atoms, and nothing more, it will know how and where to seek its food and avoid its enemies. The salmon after four years will return from the wide spaces of the Pacific to the stream where it was hatched. The queen bee will lead a swarm from the crowded hive, and the remaining bees will provide themselves with a new queen. I find all of this very improbable and hard to believe.

It may be asked: If the body is perfect chemically and physically, why should life not enter it and begin to function as it does in an embryo or as it entered the first organism on this earth? We can only answer that, so far as our experience goes, life does not behave that way. It always breaks off from some living organism and begins in the new body in a very humble, small way; whatever greater complexity and size it may attain, it gets by growth. Also, if it is necessary for something that is not matter or energy to enter, to be added to, or to take charge of, the perfect robot mechanism in order for it to produce the phenomena of life, hypothesis A cannot be true.

It also may be pointed out that the phenomena of life often appear as blind and purposeless as those of the inanimate world. A very large proportion of living things live by destroying other living things. The majority of the species produced by life have ended in failure and extinction. Life processes are easily perverted from their apparent objects: witness, cancer or the piece of embryo chicken heart that will apparently go on living and growing as long as it is properly nourished and tended, although there will never be a chicken to use it. All this and much more of the same nature is true, but it has nothing to do with hypotheses A and B. They assert nothing as to the purpose or method of life. They carefully confine the question to something for which I think we have evidence and reason sufficient to give us a satisfactory answer.

I also think there will surely be questions about those phenomena that have been recently observed and studied in connection with viruses. Many believe that they belong to a borderline, or half-life, state, that they are a link between living and nonliving matter. They seem to consist of large protein molecules. One virus, that of tobacco mosaic, has been studied intensively: it can be isolated and crystallized; it may be dissolved and recrystallized a number of times. The crystals are like other nonliving organic compounds; if, however, a living tobacco plant is inoculated with them, the leaves begin to produce more mosaic.

This action to some extent suggests that of a catalyst which brings about or stimulates chemical reaction without itself taking part in it. It is also similar to that of many chemical agents that cause a living body to generate or secrete certain substances. Viruses have no power to cause growth except in living bodies. The interesting point is that they cause the living body to produce more of the virus. As far as I know, there is no evidence that the protein molecules divide, reproduce, or grow in the manner of living cells. It is rather as if a dose of morphine caused a body to manufacture more morphine. The biochemist and the biologist will undoubtedly discover more about these curious substances, but in the present evidence I can find nothing in favor of hypothesis A or unfavorable to B.

The phenomena of the mind do not seem to be limited in time and space as are those arising from matter and energy. The following may be a poor example, and the

reader may think of others that he prefers. Nothing that happens in a distant star can affect matter upon this earth or be observed by our senses or instruments in less time than it takes light to travel from it to us, say, a million years, but knowledge of the state of the star as it was a million years ago may cause a thought about what is happening there today. This thought is a product of life, which differs in no way from a thought about what is happening in the same room as the thinker, and may result in some action by the thinker at the present time.

I have already referred to a possible exception to the rule that all phenomena of life must be perceived by senses that are designed to respond only to matter and energy.

Those who believe in telepathy as a transference or communication of thought between individuals without exchange of matter or energy will probably consider it a valid exception, not to be accounted for by hypothesis A.

A great deal more might be said from the viewpoint of psychology about our question, but I am not a psychologist and prefer to keep evidence and argument on simpler and more obvious lines. I will mention only one other point. An interesting argument might be based upon the statement that the employment or acceptance by the mind of any symbol, a word or figure that stands for something entirely different from itself, proves that something other than matter and energy is present. When matter and energy only are concerned, a word spoken or written can only produce the effects due to a certain combination of sound waves and pressures, or a particular combination of reflected light waves (or particles, if you prefer), or both. The only effects are those due to sound or light waves. When the higher forms of life are concerned, the effects produced are of an entirely different nature. The material effects received by the ear or eye are reported to the brain, where they are translated according to a prearranged code. Immaterial thoughts and emotions are produced which cannot have their origin in the purely physical effects of the reception of the energy signals. Thoughts and emotions in turn produce material action of matter and energy. All this occurs only in living things. If someone answers that pulling the trigger of a gun or dialing a number on a telephone switchboard produces effects that are very different from the energy signal received, the answer is readily apparent. Each action in the chain of dissimilar events produced is the purely physical or chemical consequence of the preceding events. The gun or the switchboard mechanism do not act because they translate a symbol into something entirely different but do what they must because of direct physical or chemical compulsion. To me, this indicates the presence of something that is not matter or energy in the working of the mind.

Perhaps some advocate of hypothesis A will say that the interpretation of the symbol by the brain is all done by purely physical or chemical processes we are beginning to understand. The point is, however, that these processes that take place in a living body—electrical generation and transmission, oxidation, osmosis, the production and transmission of chemical reagents—are correlated, regulated, controlled, and integrated by something that cannot be accounted for by any of the attributes of matter or energy.

Another quotation from Schrödinger may throw light on this aspect of the question:

> My body functions as a pure mechanism according to the laws of nature.... Yet I know by incontrovertible direct evidence that I am directing its motions, of which I foresee the effects, that may be fateful and all-important, in which case I feel and take full responsibility for them.... The only possible inference from these is, I think, that I—I in the widest meaning of the word, that is to say, every conscious mind that has ever felt or said I—

am the person, if any, who controls the motions of the atoms according to the laws of nature.

Again, one who prefers hypothesis A may ask: If the possibility of life is not inherent in matter and energy or any combination of the two, how did it begin in a lifeless world? There is of course only one sound answer: We do not know. Nor do we know how gravitation acts through millions of miles of empty space, but this in no way invalidates the fact of gravitation as a physical force and an attribute of matter (or, if you prefer, the result of the property of matter which causes curvature in space—the result is the same). I think we shall learn much more about these forces in the next thousand years. For the present we know a good deal about how they act but little, perhaps nothing, as to why.

We do know that a billion or more years ago life appeared upon this planet and began to reproduce, multiply, and develop. The first living cell was a relatively simple affair, but it contained in itself the potentialities and the plan of all the innumerable and diverse forms that exist today, from amoeba to man. This is not a theory, but an accomplished fact.

Is it possible to imagine that this enormous program was contained in the atoms and energy of the original cell or cells? Or even that the program for the growth and development of a tree or a man is contained in the atoms and energy of the fertilized cell? All we know of atoms and energy seems to me to say this is most improbable.

The alternative that the whole program was the result of chance combinations is far more improbable, more improbable than anything I can imagine.

If we cannot find an explanation for life inherent in the known properties of matter and energy and cannot accept the pure chance theory, we may suggest that it is due to the direction of some supervising power or intelligence within the universe. If this is the case, hypothesis A is untenable and B stands; the directing force is the third entity. (By definition we cannot consider a creator of the universe as "in the universe.")

I think it was Conan Doyle who said, in effect, "When I have eliminated from a problem all impossible solutions, what remains must be accepted as fact."

We set out to determine one important fact about life. Using severe economy in original assumptions we reduced our question to two simple hypotheses, one of which must be true but both of which cannot be true. I have presented such evidence as seemed to me to have a direct bearing upon the question as defined and limited by the two hypotheses.

My own conclusion is that the evidence presently available indicates such a high degree of improbability for hypothesis A that it is practically impossible to accept it except by an act of faith and a denial of reason. I have found nothing in the evidence to indicate any similar degree of improbability for hypothesis B. I must therefore reject A and accept B and believe that there are in the universe three fundamental entities, one of which, because it was a short, simple, and comprehensive word, we have called *life*.

CONSEQUENCES

While by the acceptance of hypothesis B we assert nothing about life except that it is a separate entity, the recognition of the fact should be the first step toward the study of that entity by the scientific method, which has given us all our knowledge of the other two fundamental entities. There are also several rather interesting speculations that follow as natural consequences of the definition.

For instance, it seems reasonable to suppose that some of the laws that apply to matter and energy are special cases of universal laws that apply to all three entities, just as some of Newton's laws were found to be special cases of the more univer-

sal laws developed by Einstein. If this is the case, such laws should be of the most general nature; probably they would not be defined in time or space. The conservation laws and the equality of action and reaction are of this nature. The first simply states that neither matter nor energy is destroyed or completely disappears, it simply changes form. Also we believe that neither matter nor energy is created from nothing. "*Ex nihilo nihil fit.*"

If this idea, which seems reasonable but for which I see very little hope of finding definite proof, is correct, the law of conservation applies to life. It is neither created nor destroyed, it simply changes form. The sum total of life is a constant. Perhaps the total of matter, energy, and life is a constant. It follows that life, whatever it may be, can never become nothing. Death means departure or change of form of that which made the phenomena of life possible. Where it goes or how it changes, we have not at the present time any scientific evidence, but that something becomes nothing cannot be imagined, except by blind faith that accepts a statement without question or examination in the light of present knowledge and past experience.

I think it also follows that if life is a separate entity in the universe, and the conservation law applies to it in the same sense as to matter and energy, we should be very egotistical and foolish to suppose this planet to be the only spot where it exists. There are billions of suns in our galaxy and millions, perhaps billions, of galaxies. How many suns have planets we do not know; that our solar system is unique, or even an extremely rare type, seems highly improbable. Using estimates of one hundred billion suns and one system of planets to each million suns gives us one hundred thousand solar systems in our galaxy. If we assume that each of these has one planet where conditions are such that life can exist, we have a hundred thousand habitable worlds. When we consider the tremendous range of conditions to which life has adapted itself on this world and the diversity of its forms, from bacteria to whales, from algae to men, I do not think the one planet per solar system is an unreasonable estimate. The immensity and the uniformity of that part of the universe we have been able to explore with our telescopes make it seem far more probable that there are millions of worlds containing life rather than only one.

If life came to this planet from somewhere else, and if it cannot be destroyed, it seems unreasonable to think there would be nowhere for it to go if this planet were destroyed or became untenable. If the conservation law is universal, it could not vanish into nothingness any more than the matter and energy. If our sun became a nova, our world and all it contains would probably be gasified. Some of the matter might be converted into energy and radiated into space, but not a grain of it would be destroyed in the ultimate sense. The sum total of matter and energy in the universe would be the same as it is today. Should not the same conclusion apply to life?

HUMANICS: A CRUCIAL NEED

By ROGER J. WILLIAMS

Department of Chemistry, The University of Texas

NATURAL scientists have manifested, all will agree, a greatly increased attention to social and political problems since the advent of the atomic bomb. What will be the net result of this changed attitude? Will it merely mean that they will participate more freely in established sociopolitical activities and as a result will vote more often and more intelligently and be called upon more often to give expert testimony in the fields of their competence?

May it not be that *as natural scientists* they can make special contributions of a more direct and constructive nature—contributions which no one else can make? Can it be that these unique contributions will be important, possibly even comparable to the contributions of science to the advancement of technology?

An affirmative view with respect to these latter questions may be based upon the assumption that all social and political problems center in man and upon a confidence that natural science can, if it will, make vast contributions to the better understanding of human beings. The natural-science approach to any subject involves getting to the bottom of things, and in this approach to social problems understanding the units which enter into every society becomes an inescapable necessity. It should be evident that civilization is not endangered by outside forces which we cannot control. If we are destroyed it will be an "inside job." Atomic bombs and biological warfare are of our own making and are not dangerous unless *we* make them so. We human beings are the key to our own troubles.

If natural science is to be given an opportunity to demonstrate its full usefulness in the social field, we must develop an applied or practical science of humanics which will have as its aim ***gaining scientific understanding of human beings that will be useful in solving social problems.***

The comprehensive study of man from the purely scientific standpoint is a desirable end, but what we are seeking to describe here is more restricted than this, and has to do with obtaining scientific information that gives promise of being immediately useful. As an applied science it must have its basis in pure sciences but, like other applied sciences, it must involve a number of disciplines and cut across a number of fields.

Wood technology as an applied science deals with everything that has to do with the production and use of wood. It is concerned with wood's microscopic anatomy, biological history, and even its pathology as well as the more immediate problems of sawing, milling, seasoning, and finishing. It is concerned not only with its preservation against bacteriological, mycological, entomological, and other enemies, but also with its modification, pulping, distillation, and the adaptation of it or its products to a multitude of uses. It deals not only with the chemical aspects of wood, but also its behavior as colloidal material as well as its purely physical properties. Any type of science is utilized that will contribute to a better knowledge of wood because it thereby contributes to the more effective use of wood.

It is true not only of forest products but also of other material resources, coal, oil, fisheries, soil, and agricultural products, that maximum development cannot come about until an applied science is developed

with respect to that resource—*until there are scientifically trained individuals in substantial numbers who center their attention on the particular resource in question and seek to develop its full and diversified utilization.*

If concentrated attention is required in the case of the material resources cited, how much more important is it when we deal with the paramount human resources? We need to develop the applied science of humanics, which will cut across all boundaries and devote itself to every aspect of man's existence that appears important in his social relations. It will require for its development the full gamut of the sciences from mathematics, physics, and chemistry to biology and psychology. Nothing that is important in man's life should be left out of the picture. It should be obvious that this applied science may have long-range as well as short-range objectives and is not one that can be developed overnight nor with the expenditure of a few thousand dollars. If it is worth doing, it merits being taken seriously in the same way that we take war seriously and it needs to be supported with something of the same generosity that prevailed in the case of atomic bomb investigations.

The question very naturally arises: What of the science of the past decades? Has not man been studied assiduously and intensively by experts in the various fields of knowledge? Surely scientists have not been asleep.

But the answer is a ready one: Natural science as it is related to man has very often been of a variety which does not concentrate upon those aspects that may be important in society. The idea of studying human beings scientifically and comprehensively because of the importance of the information for social control has been entertained very sparingly and by relatively few people.

From the standpoint of a practical science of humanics, our scientific study of man has had the serious limitation that we have become far more familiar with the pieces which make up the jigsaw puzzle than with how they fit together. Actual complete individuals such as make up the membership of society have not had the full searchlight of science turned upon them. In dealings with human beings we are inclined to depend upon unscientific observations and mere opinions and plausibilities rather than on scientifically gained information. In our everyday application of human science we are in the age of the oxcart.

Our piecemeal study of man has come about because it is inevitable that he should be studied by specialists who become interested in narrower and narrower segments of man's existence. It is only by such specialized study that advance can be made. But an intelligent society will not only develop, encourage, and support purely scientific study of man; it will be alert to the practicalities as well and will be constantly seeking to find and apply knowledge that is socially useful.

The general pattern for studying man scientifically has been about as follows: An anatomist, for example, makes many dissections, takes many measurements, produces many microscopic slides, and as a result learns the intimate details of body structure. Nowadays if he is to discover new information he must specialize on some part of the body, on some organ, or on some specific type of tissue. By the labors of a large number of independent anatomists, it has become possible to amass more and more complete information about the intricacies of structure of every tissue and organ in the body.

Physiologists tend to follow the same plan. Some investigate muscle physiology, some study digestion intensively, some become expert in the physiology of hearing, others investigate some phase of the circulatory system. A large number of individual specialists amass new knowledge

about the functioning of numerous organs and tissues. Biochemists try to push the curtain further back and try to determine what is transpiring, chemically, in each tissue and organ. Psychologists specialize on various phases of mental activity, and by the summation of their efforts there is accumulated a vast fund of knowledge about the diverse aspects of mental processes.

The outcome of this method of attack is that no individual investigator is encouraged to know or care about the whole picture of man or even about a large segment. The active investigators all tend to be absorbed in their respective special fields.

How has society provided for scientifically trained experts whose concern is whole men and the way they fit into society? Who is actively engaged in scientific exploration in this field? One may answer that biologists, biochemists, and psychologists are not always narrowly trained. They are all citizens and have their social responsibilities. In practice, however, what is everybody's business is nobody's business, and the responsibility for the broad scientific study of man falls exactly in that category.

It cannot be denied that a few individual scientists and individual groups have taken seriously the problem of the broad scientific study of man and its import for civilization. The Yale Institute of Human Relations is a notable example of such an effort, and there have been, and are, other such groups associated with various child welfare centers, clinics, and educational projects. These endeavors, while often meriting far more support than they have had, fall short of constituting an answer to the question that has been raised here, because in no case has a substantial amount of attention been devoted to investigation of the physiological, genetic, and biochemical aspects. Each of these is, in my opinion, far too basic and fundamental to receive minor attention or stepmotherly treatment. What is needed is a study of human beings broad enough to encompass all fundamental fields and deep enough to reach the frontiers of knowledge in the various fields.

One of the forceful pleas for the broad study of man was made over two years ago by Professor Lee R. Dice[1] who pointed out "no investigation or group or investigations now in progress is in my opinion sufficiently comprehensive to secure anything like a complete picture of man the animal, as he exists in this constantly changing world." Later in the same article he says: "... The biology of man is certainly of no less importance than the biology of dairy cows or other domesticated animals. . . . Every state should in my opinion maintain and generously support a permanent center for research on man."

Dr. Brozek and Professor Keys[2] have also pointed out the importance of "interdisciplinary research in experimental human biology" and have briefly described the work of the Laboratory of Physiological Hygiene at the University of Minnesota:

> The organization of the laboratory is built up on the conviction that a meaningful attack on the major problems of applied human physiology requires a cooperative approach. Thus physiologists, biochemists and psychologists, together with technical assistants, work as a team .... For many problems it is desirable to have ready consultation with members of other university departments—clinicians, physicists, chemists and engineers.

These scientists, as well as others who may have expressed similar views, have been doing important pioneer thinking and planning, but it should be pointed out that such work has never yet been supported by society in a substantial way. An applied science needs to be fully developed whereby scientifically trained individuals in substantial numbers will center their attention

on human beings and will seek to use all the resources of scientific investigation to further individual and social welfare.

Exactly how the applied science of humanics will develop or what lines of approach may prove most fruitful will be for the future to decide, and no one can forecast in detail the findings that may be made. In my opinion, a line of development that will prove most important concerns attention to human individuals. In the natural sciences, with some notable exceptions in the field of psychology, we have applied ourselves with singular devotion to the biological robot *man-in-the-abstract*, a hypothetical being who plays a highly questionable role in actual human society. We have not considered our scientific findings about man in a sufficiently practical light and have paid far too little attention, it seems to me, to actual human beings.

It is entirely natural and justifiable that we should, in the earlier stages of our social thinking, make the assumption that we can deal with society in a simple statistical manner and consider it to be made up of duplications of the hypothetical "average man." In this case "deviates" are unimportant in connection with an over-all picture.

If we were interested in studying society en masse and without regard to individuals, this assumption would perhaps be adequate, but actually our attitude is very much different from this, as reflected by a quotation from Einstein, a man not unacquainted with statistics, who has said, "All that is valuable in human society depends upon the opportunity for development accorded to the individual."

When we regard the welfare of individuals as of high-ranking importance (and I believe most of us do), the error of thinking in terms of man-in-the-abstract can be inconsequential or very serious, depending upon whether or not men show high variability. If we are safe in concluding that men are substantially all alike and that becoming acquainted with one acquaints us with all, then our error will be small. To the extent that this assumption is untrue, the concept of man-in-the-abstract becomes misleading and we go astray.

It seems obvious that the roots of many conflicts and many social problems lie in the very fact of individuality—our differences in appearance, in opinions, in attitudes, and in behavior—and that scientific study of human beings which has as its aim the improvement in social behavior must take account of these differences, seek out their origins, and finally develop means whereby we can adjust ourselves to them.

There is abundant scientific evidence to indicate that individuality is prominently developed in those organisms high in the evolutionary scale and that each human being possesses distinctive characteristics which appear in every segment of his existence—in his anatomy, in the details of his metabolism, in his sensory and other physiological behavior, including his endocrine system, and finally in his psychological make-up.

In view of this fact it may seem like a hopeless task to deal singly with large numbers of human beings. How can we if they are so variable and if each one matters?

The problem of caring for individual differences within a population is essentially the one that confronts the quartermaster corps which has the task of fitting shoes on the individual men in a large army. There are no two pairs of feet that are precisely alike in size and shape; yet the comfort of every individual's feet is important. For the purpose of calculating the total amount of leather required for the job, it would be necessary to know the average size of the feet to be shod. But of course the shoes cannot all be made of average size;

in this case, very few feet would be comfortable and many would have to go unshod because they would find it physically impossible to put on the average-sized shoes. Fortunately, most people's feet show some flexibility; they can be made comfortable in shoes that are approximately the right size and shape, and providing an army with reasonably satisfactory shoes is by no means impossible. In order to do so, however, the differences in foot sizes and shapes must be recognized and detailed information must be available as to the exact extent and character of the variability.

Society, in order to know how to deal with its individual units, must have at its disposal information with regard to variability—not only with respect to foot sizes and other anatomical features, but also with respect to metabolic, physiological, and psychological characteristics. These latter are fully as variable and fully as important.

Let us cite a concrete example. For instance, most of our thinking with respect to nutrition and vitamin requirements is based upon the assumption that we are dealing with a population composed of average individuals and that all will be well if we care for these. Suppose we consider specifically the status of vitamin A requirements from this standpoint.

Those who are familiar with animal assay methods for vitamin A will recall that for a test about 10 depleted rats must be fed at each level of intake. Six of these must live through the 4-week feeding period and must gain not less than 12 or more than 60 grams in order to have their performance averaged with that of their fellows.

In order for rats to perform according to these specifications, they must not only be highly inbred but must be from mothers whose diet is controlled. An unselected group of rats would show too great variability. That large variability occurs even among highly inbred rats is strongly indicated, for example, by the recent work of Sherman and Campbell,[3] who found that if members of their colony were fed vitamin A at levels two and four times that required for adequate nutrition (for 58 generations), there was a much less variable rate of growth. It appears that some rats required for optimal growth much larger amounts of vitamin A than others.

With respect to the vitamin A requirements of human beings, we should expect an even larger variation than among laboratory rats since human beings do not constitute an inbred strain. Actually, we are very much in the dark with respect to human requirements for vitamin A. In 1932 Mead Johnson and Company offered an award of $15,000 for clinical research on this subject. The terms were as follows:

> The award will be made to the investigator (or group of investigators) who (1) Determines the clinical value of vitamin A (if any) in human medicine *or* (2) Determines the vitamin A requirements of human beings *or* (3) Determines whether vitamin A in amounts more than contained in a well-balanced diet is beneficial in human physiology.

Year after year has passed without any takers for the award, and 4 of the 7 appointed judges have died. Finally after 13 years the judges, with 4 replacements, have advised the donors "that it is their considered opinion that no report or reports have been published which adequately answer *any of the three stated requirements* of the award" (emphasis supplied). They also express the belief "that no adequate answer to the problem as formulated will result from current research" and recommend that the award be revoked.[4]

In view of other pertinent facts at hand, it seems most probable that the failure to find the answers to these perfectly legitimate questions lies to a considerable extent in the high variability of human demands and the difficulty involved in obtaining consistent results. It seems entirely probable that some individuals require for

optimal health five times as much vitamin A as others. (It is notable that particularly in the case of this vitamin different assortments of wholesome foods may yield widely different amounts.)

In the long run it may be as important for an individual to be informed as to his approximate vitamin A requirement and to make use of this knowledge as it is to know his foot size and to utilize this information. With respect to the sizes and shapes of shoes, which involve merely common sense, we recognize and adapt to individual needs; with respect to vitamin A requirements, which can be known to us only through scientific investigation, we think and act in terms of man-in-the-abstract.

Instances in the biochemical field in which the differences between human individuals have received scant attention could be multiplied almost indefinitely, in spite of the potential importance of the phenomena from the standpoint of human welfare.

Investigators in practically every area of learning related to man, whether it be anatomical, biochemical, physiological, or psychological, are at least dimly aware of the fact that in their particular bailiwicks individual human differences are strikingly, and often disconcertingly, prominent. What we have failed to realize fully is how generally significant the sum total of these differences is. We have failed to grasp how these various differences influence everything we do, say, or think—our sensory reactions, our movements, our emotions, our opinions, our social adjustments. An applied science of broad scope dealing with human beings has not existed.

The potentialities residing in the applied science of humanics, which will draw on the resources of all branches of science, are so numerous that the specific examples we might discuss in a short article would hardly be more than the proverbial drops in the bucket. The large problem of education, problems of marriage, the problem of employment and choice of vocations, the problem of health, the problem of a more intelligent (and scientific) selection of leaders in every walk of life, the problem of group bigotry (whose name is legion)—all these fields of application have been discussed at length elsewhere.[5]

In many of these fields it appears to me that we think and act too much in terms of man-in-the abstract, whereas we should be thinking in terms of individual variability and individual needs. Instead of trying to nourish every developing individual with the same educational food, we should find out more about how people differ with respect to the assortment of mental abilities they possess and suit education to the different types. Human variability in the psychological realm is very pronounced, but our knowledge with regard to measurable differences is scanty in comparison with what it might be, and our adaptation of education to individual needs is most often haphazard and unscientific. Technological advance should enable us to devote more time to such problems.

There is strong reason for believing that our terrific crime problem has one of its roots in our poorly adapted education, and that potentially valuable individuals develop into criminals because they possess unusual patterns of mental traits and abilities which do not find suitable nourishment or attention in traditional schools. If we could learn how to train every individual for useful work *along the lines of his or her abilities*, the crime problem would be tremendously ameliorated. This we cannot do by thinking and planning in terms of a society composed of individuals who are substantially alike and who are to be educated alike.

The subject of the scientific study of human beings for the practical purpose of helping solve social problems is so far-reaching and important that it needs to be

encouraged and supported in every quarter. Whether I have exaggerated the importance of the study of individuals remains to be seen and is immaterial from the standpoint of the central theme. It is a fact which can hardly be controverted by scientific readers that the most effective utilization of human energies requires a scientific insight into human beings. Human beings, alike or unlike, need to be studied in a comprehensive way and not alone from the standpoint of narrow segments of their existence. Such study is not encouraged by the present organization of our universities or of our research agencies, because in these organizations an investigator necessarily belongs in one specialized group or in another. The idea that physiologists, geneticists, biochemists, and psychologists should cooperatively study human individuals for the purpose of gaining the kind of information that is essential for solving many social problems is something that is not encouraged or made possible by educational and research organizations as they now exist.

It is not desirable at this time to befog the question of the crucial need for humanics by introducing controversial questions with regard to exactly how such a science can be developed. It seems safe to say, however, that no field of research is more worthy of federal support and that when and if a National Research Foundation is established there should by all means be a provision for humanics because it is absolutely fundamental to the building of a sound social order. Certainly every state-wide or local effort which moves in the direction of understanding human beings better should be fostered; the faster the movement spreads among the nations of the earth, the greater will be the possibilities of maintaining peace.

If scientific opinion can be generated in favor of developing such a science and the public is enlightened with respect to the need, I am fully convinced that natural scientists can make outstanding contributions to the problem of social control. Is not the time ripe?

REFERENCES

1. DICE, L. R. *Science*, **99**, 457, 1944.
2. BROZEK, J., and KEYS, A. *Science*, **100**, 507, 1944.
3. SHERMAN, H. C., and CAMPBELL, H. L. Proc. Nat. Acad. Sci., Wash., **31**, 164, 1945.
4. MEAD JOHNSON & COMPANY. Advertisement appearing in *J. Amer. Med. Ass.*, Oct. 20, 1945.
5. WILLIAMS, R. J. *The Human Frontier*, Harcourt, Brace. 1946.

Book Reviews

FROM DEMONS TO DRUGS

Miracles from Microbes. Samuel Epstein and Beryl Williams. 155 pp. $2.00. Rutgers Univ. Press. New Brunswick. 1946.

THIS book was reviewed during the hours of 11:00 P.M. to 1:30 A.M. because the reviewer has that habit of so many people—namely, reading in bed—but of more momentary interest is the fact that the book was so interesting that it was read from cover to cover all in one reclining.

A foreword by Major General Norman T. Kirk points out the dynamic nature of science and leaves one with the happy thought that out of a horrible war came some advances in medicine which resulted in at least a lower rate of mortality; and thanks to penicillin many of our boys are alive today who could not have survived without the developments in the fields of antibiotics.

Chapter I, From Devils to Drugs, is a splendid review of medical treatment from medieval times to present-day antibiotics—one sees the panorama of the fifth century B.C. Hippocrates, the establishment of a medical school by Alexander the Great, the anatomical studies of Galen, the era of diagnosis but no cure, the philosophy of nature as the ideal chemist, van Leeuwenhoek's new world with the microscope, Jenner's smallpox vaccine, the Pasteur treatment, Koch's proof of the multiplication of bacteria, and Ehrlich's studies on dyes which were specific for certain bacteria. Thus was the world introduced to chemotherapy as a method of treatment of diseases.

Chapter II, A Problem in Isolation, relates the early trials and tribulations in connection with the phenomenon of antibiosis; pyocanase, pyocyanin, penicillic acid, fumigatim, and other substances were recognized. This was the period of training of men for research in a specialized field.

Chapter III is devoted to tyrothricin and the work of Dubos and others on this antibiotic. Unfortunately, this drug, isolated from *Bacilli brevis*, dissolves red blood cells, thus limiting its potential use. Solutions of tyrothricin injected into udders of cows infected with mastitis resulted in rapid cures.

So much has been written regarding penicillin that this subject is treated rather briefly in Chapter IV. The headaches of plant construction and the development of submerged fermentation technique are passed over in a few sentences, though this was the crux of industrial production. No mention is made of the research sponsored by the Office of Production Research and Development which had so much to do with the modern processes. On page 123 the authors state that "penicillin is still prepared for a grateful world by infinitesimal bacteria enlisted in the battle against their pathogenic brothers." On the previous page penicillin comes from mold.

Chapter V brings one up to date regarding streptomycin, which was discovered by Waksman and Schatz in 1943. This drug, which appears to be effective against many gram-negative organisms, is being tested against tuberculosis, leprosy, typhoid fever, Freidländer infections, tularemia, influenzal meningitis, undulant fever, and other diseases. Production is increasing rapidly, and clinical evaluation will follow.

The authors leave one with the impression that as each new form of plant life developed it must carry with it a mechanism for preventing the lower forms of life from eating it up. If so, the continued search for cures for infantile paralysis and the common cold may be discovered before long.

ALBERT L. ELDER
Corn Products Refining Co.
Argo, Ill.

THE CASE OF THE MISSING BODY

The Lost Americans. Frank C. Hibben. 196 pp. Illus. $2.50. Crowell. New York. 1946.

THIS is an entertainingly written and, one might as well add, exasperating little book. It will be read and enjoyed by that section of the public which is fond of action and mystery and which believes that the most dramatic explanation of strange events must always be the true one. Much of the action recorded here is true, the drama real. This is the story of the strangest chapter in American prehistory. It is the account of our discovery of the men who saw the last of the giant mammalian world of the American Pleistocene and who hunted its dying fauna to extinction. There are few more fascinating stories in the whole realm of archeology and few who can write about them with greater facility than Dr. Hibben. That is why I said that the book is exasperating—exasperating at least to a hardened old student of the subject like myself. It is too facile and a little too nimble here and there with its manipulation of fact.

At the very beginning *The Lost Americans* is marred by an unfortunately worded acknowledgment, the effect of which is a somewhat rude dismissal of a number of workers, by no means obscure or insignificant, who have contributed to the solution of human antiquity on this continent. Dr. Hibben says:

> The author wishes to acknowledge the help and inspiration of the *two other scientists* in the United States who have concerned themselves with the problems of the earliest Americans—the late Edgar B. Howard, of the University Museum, University of Pennsylvania; and Dr. Frank H. H. Roberts, Jr., of the Bureau of American Ethnology [italics mine].

It is entirely appropriate that the significant contributions of the late Edgar Howard and of F. H. H. Roberts, Jr., should be specifically noted, but in the three words I have italicized there is an insinuation that Hibben and the two scholars mentioned have been the only ones to concern themselves with this subject. In later pages, Hibben himself fails to be consistent on this matter, since he mentions Bryan the geologist and certain other scientists. Yet the ill-chosen words at the opening of the book leave an unpleasant impression which is many pages in being dissipated.

One may note, also, occasional statements which must be challenged in the interest of the general reader. We have, for example, no slightest idea of the life habits of *Castoroides ohioensis* which would make it possible to assert that "giant beaver built great dams across long-forgotten rivers" (p. 161). In Hibben's discussion of the extinction of the terminal Pleistocene fauna, he refers to the great bone deposits of Nebraska "where we find literally thousands of these remains together... whole herds overcome by some common power" (p. 170). Nebraska possesses probably the finest Tertiary fossil beds in the world, and many of these yield numerous remains. If, however, we pass to the terminal Pleistocene, which Hibben is actually talking about, I am afraid the statement above is, to say the least, exaggerated and I say it with due recognition of the fact that bison occasionally turn up in some number, as at the Scottsbluff quarry. In fact, Hibben himself is not consistent on this point because back on page 90 he

says: "In the Plains area. . . . where fossil bones have been found, they usually turn up in small quantities and in fragile condition."

To go on with this unfortunate catalogue, neither are the bones of mastodon to be found in Alaska in carload lots. The fact is that in this area their occurrence is extremely rare. As for Hibben's rash assertion that *Bison taylori* can be recognized and differentiated from a modern bison on the basis of a single bone (p. 116), I know of no reputable paleontologist who would dismiss the problems of bison taxonomy with quite such carefree abandon.

Nor does Hibben's assertion that the Eden Valley (Wyo.) site establishes Yuma remains as being associated with *Bison bison* entirely clarify the position of this "culture" in time. Yuma remains found at Scottsbluff were associated with long-horned bison. It is possible, of course, that Yuma is transitional to a modern fauna. But Linton Satterthwaite and Edgar Howard were unable certainly to identify the fragmentary bison remains at Eden Valley. Thus Hibben is either in possession of unpublished information of which the original excavators at Eden are unaware, or he has again ignored scientific caution for the sake of his story.

I think these quotations are enough to reveal that Hibben, in his popular writing, has a penchant for the sweeping statement and the realm of the spectacular which occasionally gets a little out of hand. Perhaps he dwells too enthusiastically on the possibilities of sudden destruction in an area where that placid old Pleistocene bovid, the musk ox, is still lingering toward his eventual disappearance.

Having said all the worst I have to say about the book, I mean no palliative when I reiterate that, though it does not (and this is perhaps wise) attempt to invade the deeper intricacies of chronology, it is a most readable introduction to the whole story of early man's intrusion into the American Ice Age world, what he saw there, and how he lived. It remains unfortunate, nevertheless, that this sketch of Folsom man, his quaint weapons, his missing body, and his weird animal associates, is presented to the interested reader through the hands of a professional archeologist who can write but for whom the plain unvarnished fact is sometimes not good enough. Dr. Hibben has it in him to become one of our ablest interpreters of archeology to the general public. His talents wait only upon a little more humility and a little more care.

LOREN C. EISLEY

Department of Sociology
Oberlin College

SOCIAL MEDICINE

Medical Education and the Changing Order. Raymond B. Allen. xviii + 142 pp. $1.50. Commonwealth Fund. New York. 1946.

THIS is the seventh of the series of monographs initiated last year by the Committee on Medicine and the Changing Order of the New York Academy of Medicine "as a contribution to contemporary thought on important questions in the general medical and health field." Several of the preceding studies have already provoked much discussion on the part of health workers. The first three were reviewed in these columns* under the heading "Prolegomena to an Inquiry into the Problems of Medical Care," amply informing readers of the composition, history, and purposes of the Committee under whose auspices these works are being presented. The author of the present volume, with degrees in both medicine and philosophy, is executive dean of the Colleges of Medicine, Dentistry and

*THE SCIENTIFIC MONTHLY, **60:** 319–320 (April 1945); **62:** 471–473 (May 1946); and **63:** 146–148 (August 1946).

Pharmacy of the University of Illinois and president-elect of the University of Washington.

This is much more than a book on medical education. It is an exposition of the author's basic philosophy, which he would probably say is scientific humanism, and which, applied to the problems of health and disease, has come to be known in Great Britain as social medicine. With this orientation he reviews the history of medicine. Using it, he analyzes such phenomena of the contemporary medical scene as licensure and certification, cultism, medical ethics, group practice of medicine, the increasing trend toward specialization, and the inadequate distribution of medical care. And in its light he examines the fundamental educational process and medical education in particular. That all these matters should be discussed in a book on medical education is eminently proper, for, as Dean Hinsey, of Cornell University Medical College, says in the preface, "it [medical education] is the keystone of the whole structure of medical practice and medical science and its quality determines their effectiveness in the service of society."

The author observes that man is at once a biological and a social organism, interacting constantly and simultaneously with his physical environment and with other units (other men and also institutions) of the social system to which he belongs. Health is present when there exists a harmonious balance both within the individual and between him and his external world. Disharmony and imbalance are disease, evidence that the body is unable to cope with untoward physical or social environmental influences. It is the same thesis which was so admirably stated by Surgeon General Parran in his speech "Charter for World Health" and which also appears in the preamble to the constitution of the new World Health Organization: "We are convinced that health is not merely the absence of disease or infirmity but a state of complete physical, mental and social well-being. . . ."

It is considered logical, therefore, by the author, that the modern approach to medicine should be not only the cure or even the prevention of illness, but rather the creation of a total situation which contributes most to man's well-being. These are the lines along which the medical curriculum must be improved.

Dean Allen believes that health is a fundamental human right. In this he also stands in firm agreement with Dr. Parran and the World Health Organization: ". . . the enjoyment of which we declare to be a fundamental right of every human being without distinction of race, religion, political belief, economic or social condition." It seems strange that this view should still need defending even after the conclusion of a victorious war for the preservation of democracy and human rights. Nevertheless, there has recently been a revival of the proposition that health is not a right but a "privilege." This point of view, however well intentioned it might be, and despite the fact that it calls itself "constructive medicine," inevitably provides grist for the mill of those who defend the *status quo* and resist changes necessary for the improvement of the nation's health. It is significant that those who consider health to be a privilege decry all attempts at "government interference," while accusing those with whom they disagree of being generally inadequate, politicians, or idealistic dreamers. Dr. Allen, who belongs in none of these categories, nevertheless believes that

> a government which attempts to do something about social, economic and industrial deficiencies and abuses in order to protect the well-being of the individual citizen is an ally of the physician in his struggle against those untoward environmental influences which make for occupational disease, maladjustment and degenerative changes in the individual.

The inadequate distribution of medical care, the reasons for which the author traces, are nothing more, he states, than a phase of the general inadequacy of our entire social and economic system of distribution of goods and services. He believes that there will be a gradual extension of both voluntary and governmental efforts, until an equilibrium between public and private services is reached. A serious responsibility of the medical school is to educate physicians in the socioeconomic problems of medical care.

The author's approach to the problem of specialization is of interest in view of the current debates on the question of "Will the Family Doctor Survive?" and the creation of a section for general practitioners at the last convention of the American Medical Association. He believes that specialists develop in response to "unsolved medical problems and the requirements of highly specialized techniques calling for great skill." But as rapidly as they in turn develop improved methods and simpler techniques, these are capable of being learned by general practitioners, and "the specialists take another self-propelled step toward oblivion." In other words, "a clinical specialty remains secure only so long as its techniques of diagnosis and treatment are so complicated and difficult that prolonged training is necessary to master them."

The statements on cultism are likewise sensible. "As the medical profession has had more of real relief from disease and suffering to offer patients, it has had less difficulty in curbing the activities of charlatans both inside and outside its ranks." The implication is obvious. It behooves the profession to attack this problem not so much by reviling the "irregulars" as by concentrating on becoming more proficient in the management of renegade patients.

Proper tribute is paid to the high quality of medical care rendered in our teaching hospitals by salaried physicians practicing as a group. "A well-organized staff exercises constant surveillance over itself." Incompetence cannot be hidden from one's colleagues under these conditions. The author neglects to point out, however, that young physicians fresh from medical school and internship, where they have received excellent training in the group practice of medicine, have in the main, under the present system of distribution of medical services, nothing to look forward to but individual practice. Many will thus have limited or no hospital affiliations, no surveillance, and no more of the intellectual stimulation which comes from contact with one's colleagues than can be found at an occasional medical society meeting. This is one of the basic paradoxes of present-day medical education. The view is expressed that

> comprehensive programs of postgraduate education for general practioners which aim to stimulate the normal processes of self-education and which give recognition of achievement by certification offer the best possibility for raising the standards of medical practice.

But no explanation is offered of how the average practitioner, surrounded as he is by competitors, may find the opportunity to leave his livelihood for significant periods of time.

On the subject of the cost of medical education and its corollary, the selection of applicants for admission to medical schools, there are statements like "economic barriers to higher education are being lowered" and "there are not enough superior and above-average students to fill the first-year classes of medical schools." This treatment will probably not receive full acceptance by realistic observers. The belief that "superior doctors are born, not made" is difficult to reconcile with the philosophical viewpoint maintained by the author.

In general, this scholarly work is such a welcome addition to the literature on the subject that it will no doubt long be remembered and quoted. It belongs in the library of every medical educator, physician, and health worker as a promise that there are more fruitful days ahead.

LEE JANIS

Washington, D. C.

SUPERSCIENCE

The Best of Science Fiction. Groff Conklin, Ed. xxvii + 785 pp. $3.00. Crown Publishers. New York. 1946.

THE editor, after a canvass of some 6,000 stories in this field of fiction, presents 40 stories which he considers "an adequate cross section of the whole field, historically as well as contextually."

He has chosen to classify the stories under the captions: The Atom, Wonders of Earth, Superscience of Man, Dangerous Inventions, Adventures in Dimension, and From Outer Space.

The authors of these tales include such well-known names as Frank R. Stockton, Edgar Allen Poe, Arthur Conan Doyle, H. G. Wells, and Julian Huxley. In an introduction, John W. Campbell, editor of *Astounding Fiction*, informs the reader that there are two research chemists, an engineer, a medical doctor, and a top-ranking mathematician in the list of authors. He further comments, "In recent years, the professional scientists have, more and more, taken over the pages of [these] magazines [of Science Fiction]."

The compiler's grouping, as listed above, suggests something of the diversity of the contents of the anthology. A perusal of the titles under a given group emphasizes that to an even greater extent. The themes of some of the seven listings under Part One, The Atom, are: International control of atomic power, superdestruction from atomic warfare, physiological and psychological effects of radioactive rays, disaster from runaway chain reactions, supermonopolies possible from atomic power. Biological, astronomical, engineering, and mathematical fantasies share in the entertainment provided in this collection along with tales from extrapolations from chemistry and physics.

The compiler emphasizes the purpose of such writings as wholly entertainment. The reviewer sees in them an added value: help for the busy scientist toward a more vivid awareness of the imaginary offspring of his prosaic generalizations. Since the achievement of atomic fission and its use for destruction scientists have become increasingly vocal regarding the uses to which their brain children are to be put, especially the energy of fission. If some find the going slow when they seek to project their thinking into the social, economic, or political worlds without their laboratory walls, perhaps science fiction may serve as a mental catalyst in initiating and facilitating that endeavor.

While there is always the possibility that the nontechnical public may take such stories too seriously, there certainly should be little hazard in their influence upon the thinking of a trained scientist. Fortunately for his purposes, most of them are reasonably short so that they can be conveniently used as a means of mental relaxation between periods of technical labor.

B. CLIFFORD HENDRICKS

Department of Chemistry
University of Nebraska

Comments and Criticisms

THE CAROLINA BAYS

It has occurred to me that it may be worth while to put into the record some facts which concern a controversy which has been touched on in the SM and in other publications over the past several years. I refer to the elliptical inland "bays" of the Carolinas.

About 1930 Fairchild Aerial Surveys, Inc., of New York City, undertook to make an aerial map of Myrtle Beach, S. C., for J. D. Lacey, Timber Factors. I was Fairchild's engineer at the time, Mr. E. R. Polley being general manager. During this general period, Professor Frank Melton, of Oklahoma University, made sporadic visits to Fairchild Aerial Surveys, Inc., to look over the files for aerial views and map photographs suitable for his use in physiography and geology, as I remember. The indicia on the photographs of Myrtle Beach had interested me greatly, and when Professor Melton next appeared I brought these photographs to his attention, remarking that they gave the appearance of the result of impact of a swarm of meteors, particularly the overlay ellipses, which cut clean segments out of the rims of other ellipses. Professor Melton was sufficiently interested to go into the matter, with the result that he and Professor Schreiber (?) made an exploratory trip to the area. What they found they wrote up and published; a number of articles followed in sequence, by various authors, popular and otherwise.

At about the time this matter came to the front, I learned from a Mr. Birney, of Fairchild Aerial Camera Corporation, and a native of the discussed Carolina area, of the existence of two or more low hills in the coastal plane, at about the border of the Carolinas and not far from the coast. Mr. Birney stated to me that these hills were unique in two respects: first, that they were hills; and, second, that they seemed to be composed of lumps of rock and iron rust. Later, he brought a sample north with him, and it appeared to me to be as stated.

I should never think of entering the controversy, as I am not qualified to pass on the evidence, being merely an engineer. I should not even hazard a guess as to whether or not the odd hills abovementioned have any bearing on the subject, but I feel justified in hoping that what they indicate may be added to the evidence, if the indications are pertinent.

In closing, I wish to remind you of the article by C. Wythe Cooke, "Neptune's Racetracks" [April 1945]. I apologize for appearing to comment on a dissertation by a scientist—I being merely an engineer—but I will say that if Cooke's solution is correct, then American industry is overlooking a source of cheap power that dwarfs the possibilities of nuclear fission. However, I was particularly impressed by the classically lyric treatment of the whole subject by Cooke, his dainty brush-off of opposing views, and the Douglasian grandeur with which he drew his cloak about him in referring to younger scientists. One would not be at all surprised if old Triton, if he could read and had read the article, blew a tattoo of derisive hoots on his wreathed horn. Perhaps, though, Cooke is right; possibly those hills of black and rusty rocks are the sole remains of Neptune's stables.—EDWIN HOWARD CORLETT.

ON THE MATHEMATICS OF COMMITTEES, BOARDS, AND PANELS

As a member of the AAAS I take the liberty of offering your editor a suggestion. In your August 1946 issue you published an article by Bruce S. Old. Is there any chance that you could be persuaded to run some reprints of that article? It will not have quite the circulation of "Message to Garcia," but it ought to have! I can think of a dozen places where I could use a copy.—EDWIN HOWARD CORLETT.

TOWARD A WORLD STATE

We are a group of young people who are trying to do something about stopping the next war. One of the most important is the teams of speakers we have on the road, distributing information and starting action groups like ours on other campuses. We badly need more and more literature like "Toward a World State," by Frederick L. Schuman.

We also publish a weekly newsletter called *The Planet*. Could we have permission to republish the very fine poem "Atomic Power," by Thomson King, which appeared in the October 1946 issue?—RICHARD ANDERSON, Students for Federal World Government.

The Brownstone Tower

THE popularly accepted age at which one begins to grow old is forty years. From then onward we should be aware of, but not too much concerned about, senescence, the gerontologists' word for aging. It is an unfortunate word because it suggests senility, but it simply means that we are not as young as we used to be. If we are wise, we will progressively adjust our activities to fit our declining physical capacities and will be on the lookout, through our physicians, for signs of diseases that are common in the period of senescence.

Being interested in the facts about senescence and their implications, I thought the majority of the readers of the SM would be interested also, for I suspected that most of them are past forty. To make sure, I took a random sample of one thousand readers from information cards that were submitted this year for the new Proceedings and Directory of the A.A.A.S. The results of my investigation apply only to male readers because I soon found that most women did not record the year of their birth. Here, then, is the age distribution of my sample in ten-year groups expressed in percent: Age 20–29, *6.3;* 30–39, *24.7;* 40–49, *25.9;* 50–59, *22.1;* 60–69, *14.7;* 70–79, *5.3;* 80–89, *1.0.*

The figures show that about two-thirds of our readers are past forty—senescent. The peak comes between forty and forty-four, but there is little change in distribution between thirty and sixty. It is an interesting fact that readers past seventy are as numerous as those in their twenties. High-school students seem to be entirely out of the picture, since the youngest reader of my sample was twenty. The oldest was eighty-nine.

I have on my desk a new book of felicitous title, *The Second Forty Years.* It implies that the span of useful life should not end at the biblical three score and ten but perhaps at four score. It is appropriate to mention this book here because it was written by our former contributing editor, Dr. Edward J. Stieglitz, is approved in a foreword by past-president A. J. Carlson, and is one of a series of popular books of broad significance sponsored by the A.A.A.S. To members who wish to purchase the book the sponsorship of the Association means that orders for it may be sent to the office of the Administrative Secretary for transmittal to the publisher, J. B. Lippincott Company.

The Second Forty Years (x + 317 pages. $2.95) is not a Pollyanna book on aging. Dr. Steiglitz, a well-known gerontologist, presents the facts about the biology of aging and describes the changes that are to be expected as we grow older. He stresses normal aging but gives adequate consideration to the hazards of senescence—the insidious diseases that may overtake us, such as hypertension, heart disease, cancer, and diabetes. Obesity, a hazard if not a disease, is thoroughly discussed. Throughout the book he points out the bearing of the facts on the life of older people. As I was enlightened by this book, I recommend it to the aged majority of our readers.

Although Dr. Stieglitz does not neglect the psychological aspects of aging in his book, he stresses the biological and medical side. Another recent book, *Aging Successfully*, by George Lawton, is predominantly psychological. A chapter from this book, "Old Age: Minus and Plus," was published in the January issue of the SM. With these two books now available it is our own fault if, through ignorance, we fail to make the most of our second forty years.

F. L. CAMPBELL